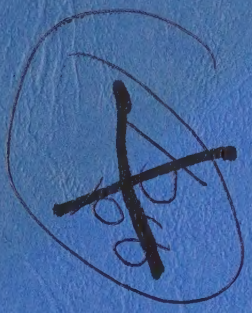
0A110

VIKING LABORATORIES, INC.

strip chart recorder



# series G-2000

# INSTRUCTION MANUAL

varian aerograph
2700 mitchell drive/walnut creek/california 94598/415-939-2400
specialists in chromatography and data handling systems

SERIES G–2000

STRIP CHART RECORDERS

Copyright © 1968 by Varian Aerograph
All Rights Reserved
Manufactured in the United States of America

Printed in U.S.A.
September 1968

Publication No.
87-300-112A

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_09967

varian aerograph
recorder products

# WARRANTY

All instruments and accessories sold by Varian Aerograph are warranted for a period of one year against defects in materials and workmanship. The terms of this warranty are as follows:

1. The warranty period begins with the shipping date of the equipment to the original purchaser.

2. Certain parts such as batteries, fuses, glass accessories, chart paper, vacuum tubes, etc., are expendable in normal use, and their service life is unpredictable. Such expendable items are not covered by this warranty.

3. All requests for service or repair under this warranty must be received within the warranty period by Varian Aerograph or its authorized representative.

4. All repairs, adjustments, and other service under this warranty shall be performed free of charge to the purchaser. However, warranty service and repairs shall be limited to equipment malfunctions which, in the opinion of Varian Aerograph, are due or traceable to defects in original materials or workmanship. Instrument malfunctions caused by abuse or neglect of the equipment are expressly not covered by this warranty.

5. Instrument parts which have been repaired or replaced during the warranty period are themselves warranted only for the remaining unexpired portion of the original one year warranty.

6. Repairs, adjustments, and service performed after expiration of the one year warranty period shall be charged to the purchaser at the then current prices for parts, labor, and transportation.

7. Varian Aerograph expressly disclaims any liability to users of its products for consequential damages of any kind arising out of or connected with the use of its products.

8. Except as stated in Sections 1 through 8 above, Varian Aerograph makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except as stated in Sections 1 through 8 above, Varian Aerograph shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

9. Statements made by any person, including representatives of Varian Aerograph, which are inconsistent or in conflict with the terms of this warranty shall not be binding upon Varian Aerograph unless reduced to writing and approved by an officer of the Company.

10. This warranty shall be governed by the laws of California.

LITHO IN U.S.A.
© SOES 746

# TABLE OF CONTENTS


| | | Page |
|---|---|---|
| SECTION 1 - INTRODUCTION | | |
| 1.1 | General | 1-1 |
| 1.2 | Construction | 1-2 |
| 1.3 | Specifications | 1-2 |
| 1.4 | Equipment Supplied | 1-4 |
| 1.5 | Accessories and Options | 1-4 |
| 1.6 | Single Span Recorders | 1-6 |
| SECTION 2 - INSTALLATION | | |
| 2.1 | General | 2-1 |
| 2.2 | Visual Inspection | 2-1 |
| 2.3 | Installation of Accessories | 2-2 |
| SECTION 3 - OPERATION | | |
| 3.1 | General | 3-1 |
| 3.2 | Installation of Chart Paper | 3-1 |
| 3.3 | Installation of Pen Assembly and Ink Cartridge - Main Recorder Pen(s) | 3-2 |
| 3.4 | Installation of Ink Cartridges - Event Marker Pen(s) | 3-2 |
| 3.5 | Primary Power Requirements | 3-2 |
| 3.6 | Signal Source Connections | 3-3 |
| 3.7 | Controls and Calibration Adjustments | 3-3 |
| 3.8 | Modes of Operation | 3-4 |
| 3.9 | Electrical Inspection | 3-6 |
| 3.10 | Recorder Operation | 3-9 |
| 3.11 | Operating Remarks and Recommendations | 3-10 |

SECTION 4 - SERVICE AND MAINTENANCE

| | | Page |
|---|---|---|
| 4.1 | General | 4-1 |
| 4.2 | Field and Factory Service | 4-1 |
| 4.3 | Preventive Maintenance | 4-2 |
| 4.4 | Lubrication | 4-3 |
| 4.5 | Solid State Circuitry Techniques and Precautions | 4-3 |
| 4.6 | Troubleshooting | 4-7 |
| 4.7 | Disassembly | 4-8 |
| 4.8 | Calibration | 4-12 |
| 4.9 | Restringing Pen Drive Cable | 4-18 |
| 4.10 | Potentiometer Phasing | 4-23 |
| 4.11 | Chart Drive Motor Replacement | 4-24 |
| 4.12 | Potentiometer Replacement | 4-25 |
| 4.13 | Conversion Between Side-By-Side (5-inch span) and Cross-Over (10-inch span) Pen Systems | 4-27 |

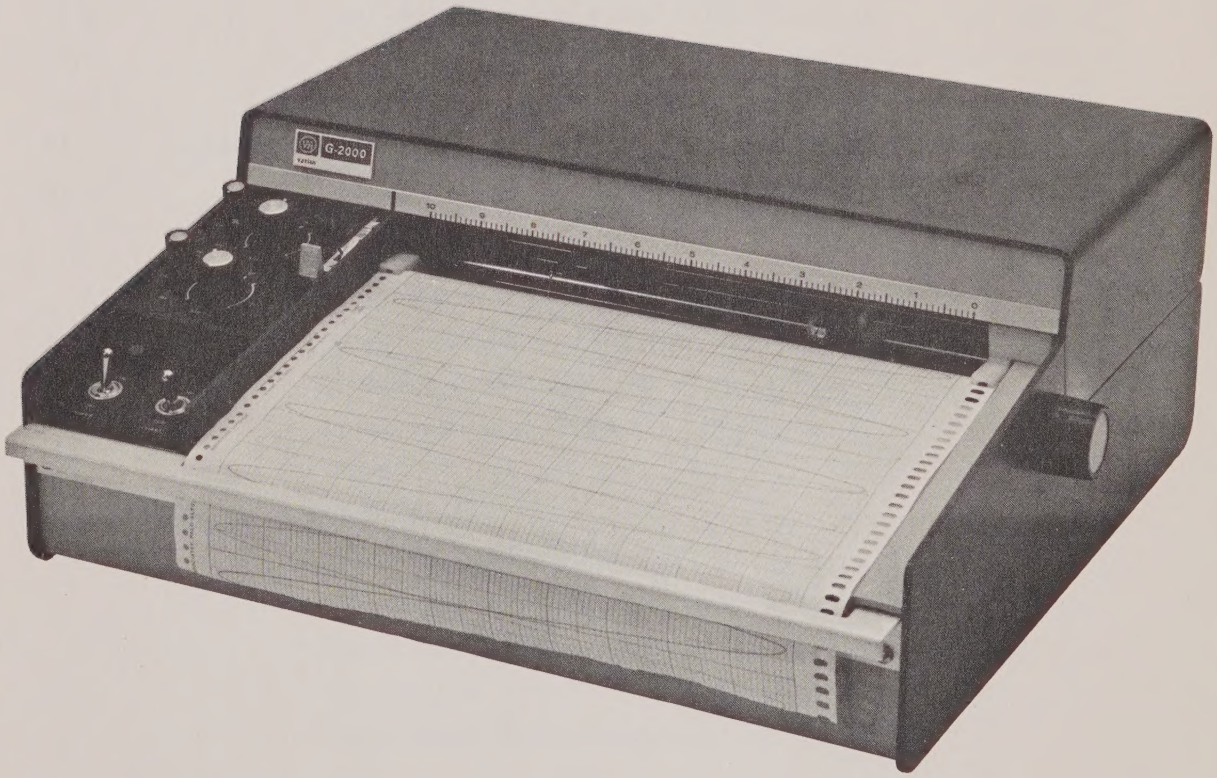
SECTION 5 - PARTS LISTS

| | | |
|---|---|---|
| 5-1 | Chart Drive Motor Assemblies | 5-1 |
| 5-2 | Electrical Parts Lists - Basic Recorders | 5-1 |
| 5-3 | Electrical Parts Lists - Accessories and Options | 5-1 |
| 5-4 | Replacement Parts, Supplies, and Kits | 5-1 |

SECTION 6 - SCHEMATIC DIAGRAMS 6-1

# LIST OF TABLES


| | | Page |
|---|---|---|
| TABLE I | Span Element - Model Number Cross Reference List | 1-7 |
| TABLE II | Troubleshooting Chart | 4-5 |
| TABLE 5-1 | Standard Chart Drive Motor Assemblies | 5-2 |
| TABLE 5-2 | Optional Chart Drive Motor Assemblies | 5-2 |
| TABLE 5-3 | Electrical Parts Lists - Basic Recorders | 5-3 |
| TABLE 5-4 | Electrical Parts Lists - Accessories and Options | 5-13 |
| TABLE 5-5 | Replacement Parts, Supplies, and Kits | 5-14 |


G-2000

# SECTION 1
# INTRODUCTION

## 1.1 GENERAL

Varian Series G-2000 ten-inch strip chart recorders are null-balance potentiometric instruments for use with laboratory and process control readout devices. These solid-state recorders are functionally styled to complement the many popular types of modern analytical instruments now in service. The bench-top configuration provides a large number of operator conveniences.

Both single channel and dual channel recorders are offered; three versions of dual channel units are available:

1. Overlapping pens - 3/32" maximum offset on time axis; full chart coverage.
2. Cross-over pens; same time axis; full chart coverage.
3. Side-by-side pens; same time axis; one-half chart coverage with each pen.

The following table gives model numbers for these configurations:

| | One Pen | Two pens Different time axis 10-inch span | Two pens Same time axis 10-inch span | Two pens Same time axis 5-inch span each |
|---|---|---|---|---|
| Multispan Model No. | G-2010 | G-2020 | G-2022 | G-2025 |
| Single Span Model No. | G-2110 | G-2120 | G-2122 | G-2125 |

The right-hand channel, when facing the front of the recorder, corresponds to the front pen on dual channel units.

Special versions of the G-2000 series of recorders can be supplied for specific applications.

Multiple span G-2000 recorders have a 10-position calibrated span switch with vernier control allowing operator choice of spans from 1 millivolt to 1 volt. With single-span recorders, a plug-in span element replaces the 10-position switch.

1.1 Continued

Each recorder is supplied with two chart drive motors and a 4-position thumbwheel chart speed shifter (RATIO control) which provides eight speeds in binary ratios. Either or both motors may be changed in the field to obtain other chart speeds as desired.

Other accessories include event markers, retransmitting potentiometers, alarm control switches, electric pen lifting mechanism and a folded chart paper system, all of which can be either field or factory installed. Accessories which must be factory installed are a Disc integrator, and reversed polarity circuitry.

## 1.2 CONSTRUCTION

The basic recorder is constructed on a sheet metal chassis. All mechanical and electromechanical components are mounted on this chassis assembly. The platen, offering ample space for making chart notations, is hinged for easy chart paper loading, and a chart paper tear-off bar is mounted across the front of the recorder. The top is hinged and tilts upward to provide quick access to the ink system and the optional integrator switch.

The power switch with indicator light and the chart drive motor switch are conveniently located on the control panel at the front of the recorder. On multiple span units (Models G-20xx), the span switch(es) and vernier control(s) are also located on the control panel. Signal input terminals, plug-in single-span element(s) (Models G-21xx), accessory connector, fuse holder, power cord input, and calibration controls and adjustments are located at the rear of the chassis.

## 1.3 SPECIFICATIONS

All specifications apply to line voltage of 105-125 vac at 60 $\pm$2 Hz or 210-240 vac at 50 $\pm$ 2 Hz.

| | |
|---|---|
| Span (full scale voltage) | 10-position, calibrated switch: 1, 2, 5, 10, 20, 50, 100, 200, and 500 mv; 1 volt. Uncalibrated potentiometer for adjustment between spans. Single span, plug-in element optional. |
| Input | Floating, differential; input signal may be $\pm$200 vdc, maximum, from chassis ground. Low pass input filter optional.* |
| Input Resistance | Potentiometric on 1 mv through 100 mv spans; 1 megohm on 200 mv through 1 volt spans; 50K ohms on uncalibrated spans. |

* Low pass filter affects pen response, line frequency rejection, and permissible source resistance specifications.

1.3 Continued

| | |
|---|---|
| Permissible Source Resistance | Up to 50K ohms on calibrated spans. |
| Line Frequency Rejection | |
| Normal Mode (Transverse) | 60 db (1000 to 1) |
| Common Mode (Longitudinal) | 140 db ($10^7$ to 1) |
| DC Rejection | 140 db or 200 volts, whichever is less. |
| Pen Response (50 and 60 Hz) | 0.5 second, full scale |
| Accuracy | 0.25% of full scale. |
| Sensitivity | 0.1% of full scale (10-inch span), or 1 microvolt, whichever is greater. |
| Reference Voltage | Electronically regulated (Zener). |
| Zero Adjustment | Full scale. |
| Zero Suppression | One scale width. |
| Damping | Adjustable. Changes in damping do not affect dc calibration. |
| Ambient Temperature | $32^{o}$ to $110^{o}$F. |
| Paper | W = 11-5/16 inches; L = 120 feet. |
| Chart Motor Speeds | 1, 2, 4, and 8 inches/minute; 1, 2, 4, and 8 inches/hour. Others on special order. See Table 5-1. |
| Grid Size | 10" maximum. |
| Dimensions | H = 6-1/4"; W = 15-1/2"; D = 15-1/2". |
| Weight | |
| Single Channel Recorder | Net: 23 pounds; Shipping: 28 pounds. |
| Dual Channel Recorder | Net: 29 pounds; Shipping: 34 pounds. |
| Power Requirements | 105 to 125 vac or 210 to 240 vac; 58 to 62 Hz or 48 to 52 Hz; 30 watts, single channel; 60 watts, dual channel. |

## 1.4 EQUIPMENT SUPPLIED

The recorder is shipped with all of the necessary components required for immediate operation. Standard items and supplies include:

| Varian Part Number | Description | Quantity Single Channel | Quantity Dual Channel |
|---|---|---|---|
| 87-300-112A | Instruction Manual | 1 | 1 |
| 908-049-01 | Ink cartridge, red | None | 4 |
| 908-049-02 | Ink cartridge, blue | 2 | 4 |
| 972-735-01 | Single or Front pen assembly | 1 | 1 |
| (Per S/O) | Rear pen assembly | None | 1 |
| 907-674 | Pen filler | 1 | 1 |
| 972-499 | Pen cleaning wire | 1 foot | 1 foot |
| (Per S/O) | Chart paper | 1 roll | 1 roll |
| 88-299-450 | Motor oil | 1 oz. | 1 oz. |
| 972-529 | Chart-weight clip | 1 | 1 |
| 907-214 | Power cord | 1 | 1 |
| (Per S/O)* | Fuse | 2 | 2 |
| | Registration card | 1 | 1 |

* See paragraph 2.2. for listing of fuses.

## 1.5 ACCESSORIES AND OPTIONS

### 1.5.1 Integrator

An automatic integrator may be factory-installed on both single and dual channel recorders. This unit, designed by Disc Instruments, Inc., provides an auxiliary pen trace representing the area under the main recorded curve. The integrator pen operates in the right-hand chart margin.

### 1.5.2 Event Marker

The timing of significant events can be marked precisely on the chart by using the optional event marker pen. A dual action marker pen, with a separate ink supply, can be installed in either chart margin, or in both margins. Operated by positive-acting solenoids and an internal power supply, they require only an external contact closure for actuation. The same internal power supply is used for any combination of event markers and the electric pen lift mechanism. Power is furnished to event markers only when the CHART switch is in either

1.5.2 Continued

the LOW or HI position. Event markers may be either factory or field installed; see paragraph 2.3.4 for field installation instructions; see paragraph 3.10.2 for operating instructions. See Table 5-3 for listing of electrical parts.

1.5.3 Electric Pen Lift

Series G-2000 recorders have provision for factory or field installation of a solenoid-actuated pen lifting mechanism. Thus, a remote switch or relay can be used to control pen lowering and lifting. The same internal power supply is used for the pen lifting mechanism and any combination of event markers. The electric pen lift is connected through the CHART switch so that the pen automatically raises when the CHART switch is OFF and lowers when the CHART switch is in either the LOW or HI position. The remote switch or relay for operation of the electric pen lift is to be connected between pins P and R of P406, the multipin mating plug connector for receptacle connector J406 mounted at the rear of the recorder. See the Wiring Diagram in Section 6. See Table 5-3 for listing of electrical parts. See paragraph 2.3.3 for instructions for field installation of the electric pen lift.

1.5.4 Alarm/Control Switches

Each recording channel may be equipped with simple auxiliary switches that control low-power external circuits. Contacts can be adjusted to operate at various predetermined points across the width of the recorder scale. Contacts are SPDT, momentary actuation. Voltage rating is 250 vac, maximum; current rating is 5 amps, maximum.

Alarm/control switches may be either factory or field installed. See paragraph 2.3.1 for field installation instructions.

The quantity of alarm/control switches which can be installed is as follows:

| Recorder Version | Number of Switches |
|---|---|
| Single channel | Up to 6 |
| Dual channel | |
| Side-by-side pens | Up to 3 per channel |
| Overlapping or cross-over pens | Up to 6 on rear channel; none on front channel |

1.5.5 Folded Chart Paper

Series G-2000 recorders have provision for operation with a convenient type of folded paper which may be used in lieu of conventional roll charts. Each pack consists of a continuous length of paper that is perforated and folded every 8 inches to allow ease of handling and rapid inspection of large amounts of data. Each page in the pack is numbered, and individual sheets can be

1.5.5 Continued

quickly located and easily removed. Folded packs are available in 200- and 800-sheet sizes. See the Varian Recorder Supplies Catalog for part numbers and prices. A holder for the folded chart paper, which may be placed under the recorder, is available. Refer to paragraph 2.3.6 for instructions for field installation.

1.5.6 Retransmitting Potentiometer

Either or both channels can be equipped with a retransmitting potentiometer. It is supplied with a standard feedback potentiometer as an integral unit. Standard resistance is 3K ohms; several nonstandard resistances are also available. The unit may be either factory or field installed. See paragraph 2.3.5 for field installation instructions.

1.5.7 Reversed Polarity Circuitry

Optional reversed polarity circuitry permits the reversal of zero position on the chart (example: left-hand to right-hand margin) and reverses the direction of pen travel with increasing positive signals. Modification of a recorder from standard to reversed polarity circuitry should be performed at the factory.

1.6 SINGLE SPAN RECORDERS

For applications where a single, fixed span per channel is desired, Models G-21xx offer a plug-in span element mounted at the rear of the recorder. Elements of 10 different voltage spans are standard - others on special order.

Since the span on the dual channel, side-by-side pen system recorder (Model G-2125) is essentially 5 inches for each channel, the elements for this recorder differ from the standard 10-inch span elements. Table I lists the Varian part numbers according to recorder model number.

1.6 Continued

TABLE I

Span Element - Model Number Cross Reference List

| Span | Span Element Part Number<br>Models G-2110, G-2120, G-2122 | Model G-2125 |
|---|---|---|
| 1 mv | 972-261-01 | 972-261-02 |
| 2 mv | 972-261-03 | 972-261-04 |
| 5 mv | 972-261-05 | 972-261-06 |
| 10 mv | 972-261-07 | 972-261-08 |
| 20 mv | 972-261-09 | 972-261-10 |
| 50 mv | 972-261-11 | 972-261-12 |
| 100 mv | 972-261-13 | 972-261-14 |
| 200 mv | 972-261-15 | 972-261-16 |
| 500 mv | 972-261-17 | 972-261-18 |
| 1 v | 972-261-19 | 972-261-20 |

# SECTION 2
# INSTALLATION

## 2.1 GENERAL

Each Series G-2000 recorder is shipped complete in one commercial-grade shipping container. If the container has been damaged in transit, notation of the damage should be made on the shipping receipt. If the recorder and/or accessory items have been damaged, notify the carrier claim agent. He will provide instructions and forms for reporting and describing the damage.

> **CAUTION**
>
> DO NOT ATTEMPT TO OPERATE DAMAGED EQUIPMENT.

When unpacking the recorder, check carefully to insure that all components ordered have been supplied. If there are any discrepancies, notify Varian Recorder Division immediately. The packing box should be retained for use should the instrument need to be returned for repair or accessory installation. Fill out and mail the registration card which insures that the warranty will be validated.

After unpacking the recorder, it should be given a visual inspection as outlined below.

## 2.2 VISUAL INSPECTION

The recorder and accessory items should be visually inspected to assure that no damage to the equipment has occurred in transit. The points to be covered are the following:

1. The pen carriage(s) should move smoothly over the full excursion.

2. All screws should be tightly secured.

2.2 Continued

3. Check that all switches operate properly.

4. Turn the paper advance knob at the side of the recorder to assure that the sprocket drum turns smoothly.

5. Check that the correct fuse is properly inserted in its holder.

Correct fuse values are as follows:

| Power Requirement | Recorder | Slo-blo Fuse | Varian Part Number |
|---|---|---|---|
| 115V, 60 Hz | Single Channel | 0.5 amp | 67-135-350 |
| 115V, 60 Hz | Dual Channel | 1.0 amp | 67-135-410 |
| 230V, 50 Hz | Single Channel | 0.25 amp | 67-135-325 |
| 230V, 50 Hz | Dual Channel | 0.5 amp | 67-135-350 |

When the recorder is ready for operation, proceed to Section 3 - OPERATION. Read all applicable paragraphs of Section 3, install chart paper, pen assemblies, and ink cartridges, and give the recorder an electrical inspection before operating the instrument for the first time.

After it has been determined that the recorder is operating properly, proceed to paragraph 3.10.1 for detailed operating instructions.

## 2.3 INSTALLATION OF ACCESSORIES

### 2.3.1 Installation of Alarm/Control Switch(es)

The alarm/control bracket for the rear pen (second channel) is supplied on every recorder. See paragraph 1.5.4 regarding quantity and location of alarm/control switches. On single channel recorders, however, only the front pen is used, so the alarm/control bracket must be installed.

STEP 1 On single channel recorders, mount the alarm/control bracket to the left-hand and right-hand frames with 6-32 screws. See Figure 2-1.

STEP 2 Remove the thumb nut from the alarm/control switch.

STEP 3 Insert the 4-40 switch stud through the alarm/control bracket from the rear. The ears on the switch engage the slot in the bracket.

STEP 4 Replace the thumb nut, but do not tighten.

STEP 5 Follow Steps 1 through 3 for all switches being installed.

STEP 6 Place the alarm/control switch(es) in desired position(s) and tighten the thumb nut(s).

STEP 7 Connect the alarm/control switches to connector J406. See wiring diagram in section 6 for correct connections.

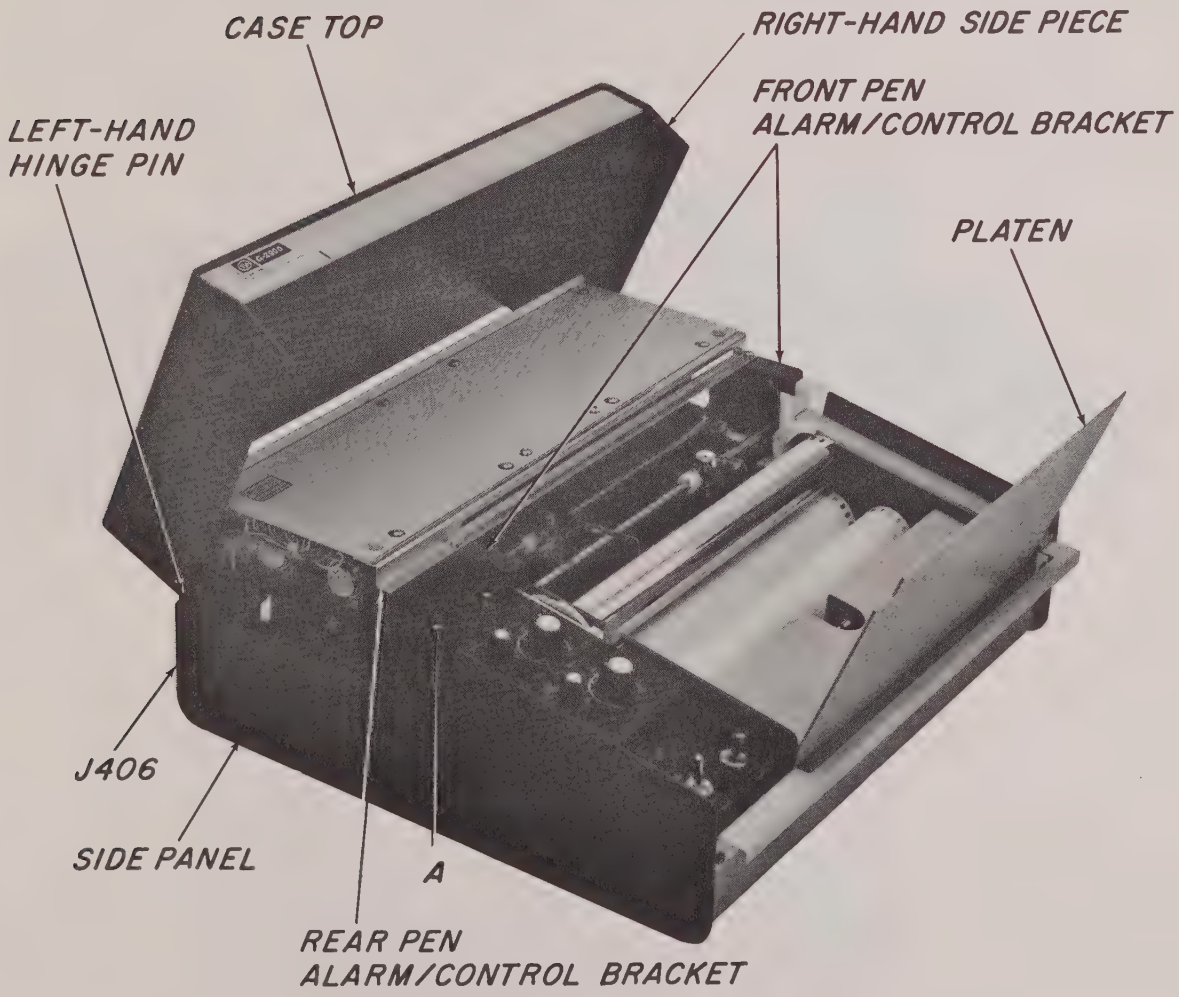



**Figure 2-1. G-2000 Recorder Major Components**

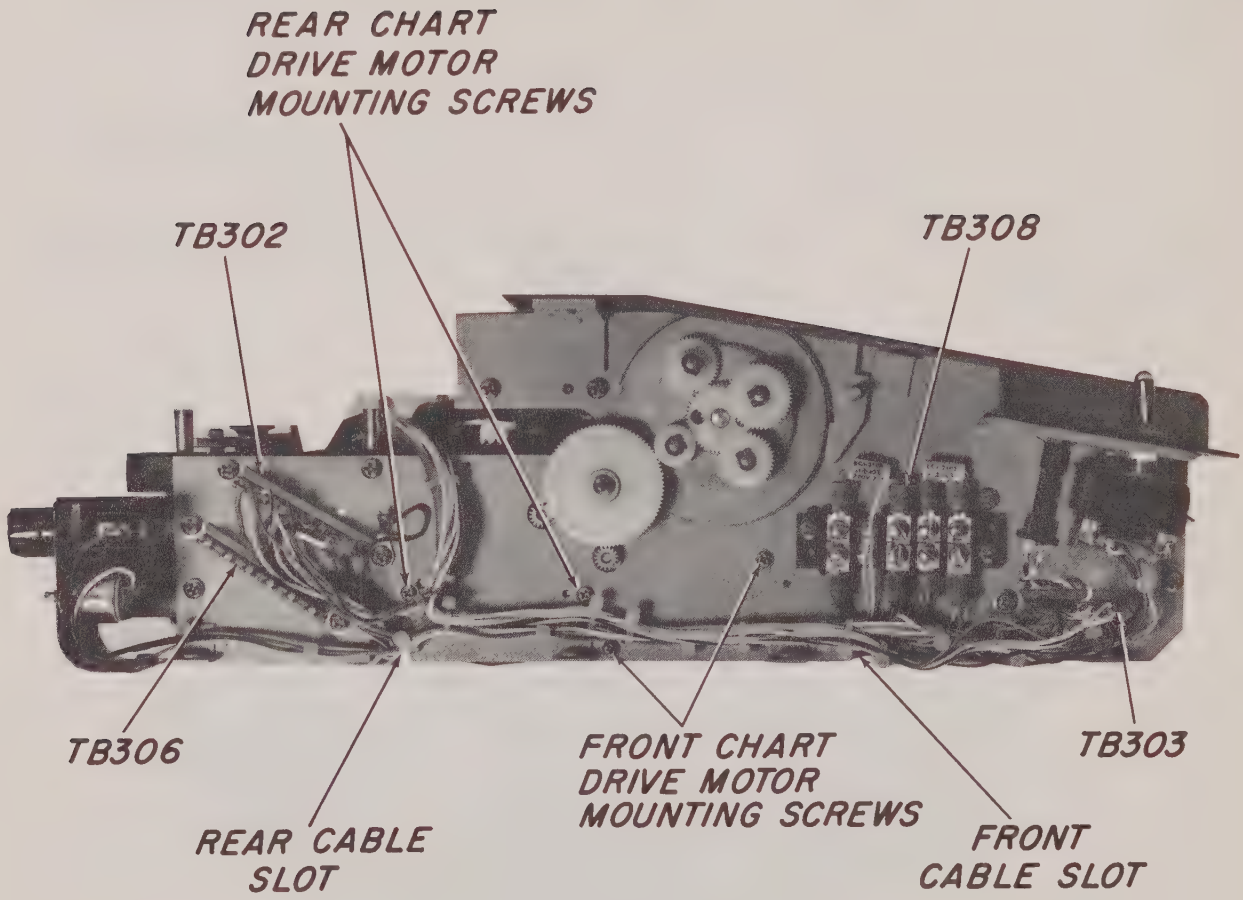

REAR CHART
DRIVE MOTOR
MOUNTING SCREWS
TB302
TB308
TB306
REAR CABLE
SLOT
FRONT CHART
DRIVE MOTOR
MOUNTING SCREWS
TB303
FRONT
CABLE SLOT

Figure 2-2.

Figure 2-3. Accessory Power Supply Assembly

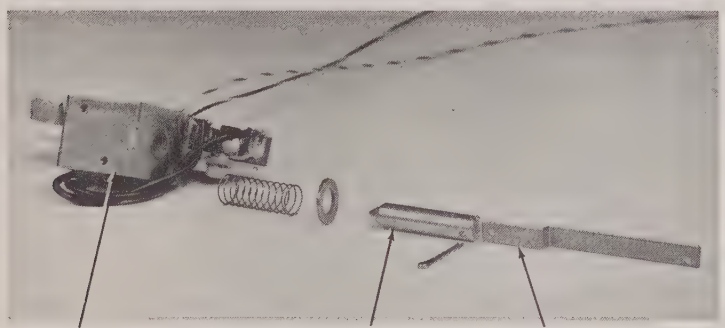



Figure 2-4. Electric Pen Assembly

Figure 2-5. Event Marker Assembly

## 2.3.2 Installation of the Accessory Power Supply

The electric pen lift and the event marker accessories for the Model 2000 recorder are powered by the accessory power supply. Figures 2-3, 2-4, and 2-5 show the assemblies before they are installed on the recorder. The accessory power supply is installed first, then the electric pen lift and the event marker are added. Refer to section 6 for a wiring diagram and a schematic of the recorder with accessories.

STEP 1 Prepare the recorder for the installation of the accessory power supply by removing the pen(s), the chart paper, and the integrator ink cartridge, if present.

STEP 2 Remove the case top by tilting the top upward, grasping the rear edge of the right-hand side piece, and springing the side piece away from the recorder to disengage it from the right-hand hinge pin. See Figure 2-1. Move the top to the left to disengage it from the left-hand hinge pin.

STEP 3 Hold the platen and turn the recorder upside down.

STEP 4 Remove the eight screws numbered 1 through 8 in Figures 4-1 and 4-2 and remove the bottom screen. (It is not necessary to remove the screws in the recorder feet.)

STEP 5 Loosen the two 6-32 set screws in the paper advance knob and remove the knob.

STEP 6 Remove the six screws numbered 11 through 16 in Figure 4-1 and remove the side panels from the recorder.

STEP 7 Position the accessory power supply terminal board TB305 and the accessory power supply transformer T301 on the recorder as shown in Figure 2-6. Route the wires between the slidewire potentiometers.

STEP 8 Secure the terminal board and the transformer using the four No. 6-32 Phillips-head screws provided. See Figures 2-6 and 4-4.

STEP 9 Connect the green wire from the accessory power supply to terminal 6 of TB302. See Figure 2-2. Route all wires along existing harness where possible. Refer to the wiring diagram in section 6.

STEP 10 Connect the black wire from the accessory power supply to the HIGH terminal of switch S302B. See Figure 2-8.

STEP 11 Connect the white/orange wire from pin 2 of TB305 (Figure 13) to pin 10 of TB301 (Figure 2-9).

STEP 12 Proceed with the installation of the electric pen lift or the event marker.

### 2.3.3 Installation of Electric Pen Lift

After the accessory power supply is installed, the electric pen lift may be installed as follows:

STEP 1 Loosen the two Allen-head set screws and remove the four sections of linkage on the right side of the recorder. See Figure 2-7.

STEP 2 Remove the two servo mounting plate screws from the side panel. See Figure 2-7.

> NOTE
>
> If an event marker cartridge clip is installed under the rear servo mounting plate screw, remove the cartridge clip before installing the pen lift solenoid assembly.

STEP 3 Fasten the pen lift solenoid assembly to the side panel using the two servo mounting plate screws. See Figure 2-10.

STEP 4 Assemble the slotted linkage arm replacing the existing linkage arm as shown in Figure 2-11. Use the new cotter pin furnished with the kit.

STEP 5 Attach the pen lift solenoid link using a cotter pin. See Figure 2-11.

STEP 6 Attach the plunger to the pen lift solenoid link using a cotter pin. Slide the washer and spring over the plunger. See Figures 2-4 and 2-12.

STEP 7 Replace the linkage assembly on the recorder. Press the pen lift linkage to bottom the plunger in the solenoid, lift the pens 1/8 inch off the platen, and tighten the two set screws. See Figure 2-12.

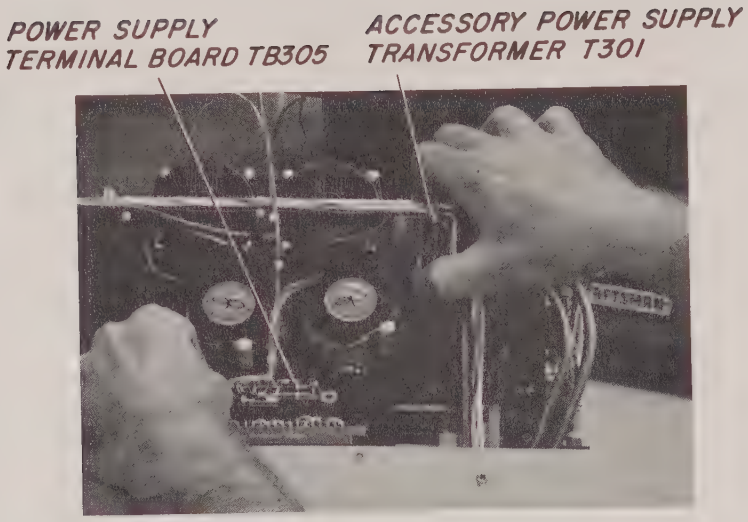



Figure 2-6. Accessory Power Supply Installation

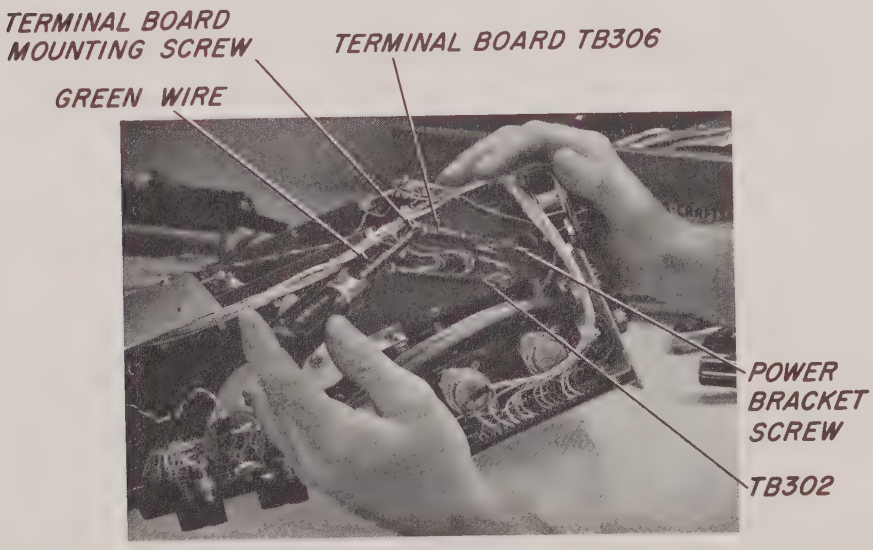



Figure 2-7. Terminal Board Installation

NOTE

If the plunger binds on the side of the solenoid, adjust the position of the solenoid.

STEP 8 Connect resistor R303 (51-ohm for 115 V 24-ohm for 230 V ) between terminals 6 and 8 of TB305. See Figure 2-13. Refer to wiring diagram in section 6.

STEP 9 Connect the black/white wire from the terminal nearest the solenoid on the pen lift solenoid assembly (TB307-2) to terminal 8 of TB305. See Figures 2-10 and 2-13. Route all wires along existing harness where possible.

STEP 10 Connect the yellow/red wire from the terminal farther from the solenoid on the pen lift solenoid assembly (TB307-1) to pin R of connector J406. Route the wire through the J406 opening on the power panel. See Figures 2-10 and 2-14.

STEP 11 Connect the yellow/green wire from terminal 3 of TB305 to pin P of connector J406. See Figures 2-13 and 2-14.

STEP 12 If an event marker is to be installed, proceed to paragraph 2.3.4. If not, reassemble the recorder by the following steps.

STEP 13 Insulate the ends of the power supply wires which are loose and tie down all wires so they do not interfere with the mechanical operation of the recorder.

STEP 14 Replace the side panels on the recorder and hold in place with the six screws numbered 11 through 16 in Figure 4-1.

STEP 15 Replace the bottom screen and fasten with the eight screws numbered 1 through 8 in Figures 4-1 and 4-2.

STEP 16 Replace the case top by edging the left-hand hinge pin, grasping the rear edge of the right-hand side piece, and springing the side piece away from the recorder so it will engage the right-hand hinge pin. See Figure 2-1.

## 2.3.4 Installation of Event Markers

After the accessory power supply is installed, the left-hand and right-hand event markers may be installed as follows:

STEP 1 Fasten terminal board TB306 to the side of the recorder using the two screws as shown in Figure 2-7.

STEP 2. Place the event marker pen assembly in the location shown in Figure 2-15 and secure to the rear pen alarm/control bracket with two Phillips flat-head No. 4 screws.

> NOTE
>
> Figures 2-15 and 2-16 show the left-hand event marker. Install the right-hand event marker using the right-hand mounting holes. See Figure 2-15.

STEP 3 Route the wires under the rear pen alarm/control bracket to terminal board TB306. See Figure 2-7.

STEP 4 Connect the wires from the left-hand event marker pen assembly as follows:

a) gray wire to terminal 2 of TB306
b) blue wire to terminal 3 of TB306
c) green wire to terminal 4 of TB306

STEP 5 Connect the wires from the right-hand event marker pen assembly as follows:

a) green wire to terminal 4 of TB306
b) yellow wire to terminal 5 of TB306
c) white wire to terminal 6 of TB306

STEP 6 Connect the yellow/green wire from terminal 3 on TB305 to terminal 1 of TB306.

STEP 7 Connect the wires from terminal board TB306 to connector J406 and terminal board TB302 as follows:

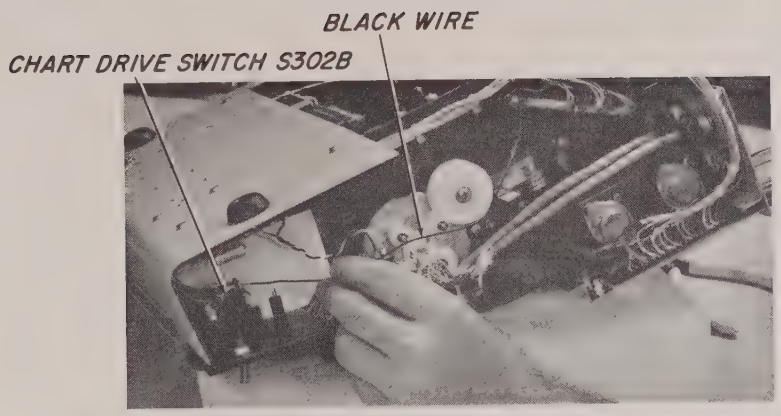



Figure 2-8. Location of Chart Drive Switch

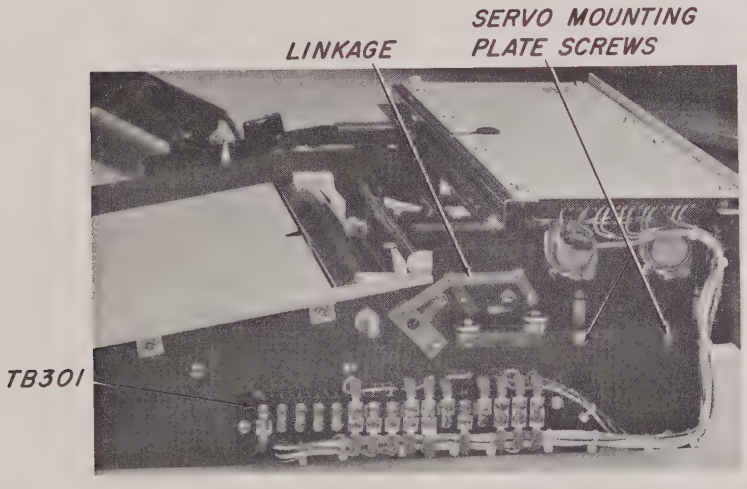



Figure 2-9. Right-Hand Side View of Recorder

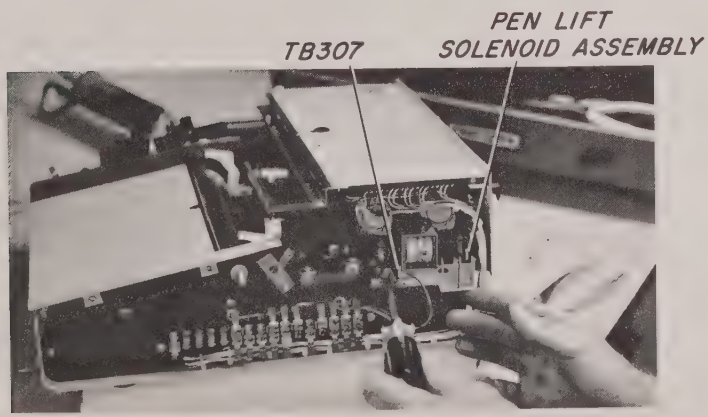



Figure 2-10. Location of Pen Lift Solenoid Assembly

LEFT-HAND EVENT MARKER WIRING

| WIRE COLOR | FROM TERMINAL | TO TERMINAL |
|---|---|---|
| yellow/green | 1 of TB306 | P of J406 |
| gray | 2 of TB306 | K of J406 |
| blue | 3 of TB306 | L of J406 |
| green | 4 of TB306 | 6 of TB302 |
| green | 6 of TB302 | 6 of TB305 |

RIGHT-HAND EVENT MARKER WIRING

| WIRE COLOR | FROM TERMINAL | TO TERMINAL |
|---|---|---|
| yellow/green | 1 of TB306 | P of J406 |
| yellow | 5 of TB306 | M of J406 |
| white | 6 of TB306 | N of J406 |
| green | 4 of TB306 | 6 of TB302 |
| green | 6 of TB302 | 6 of TB305 |

STEP 8 Mount connector J406 to the power bracket using the two slotted screws provided.

STEP 9 If an electric pen lift is to be installed, follow the procedure in paragraph 2.3.3. If not, reassemble the recorder as described in the following steps.

STEP 10 Insulate the ends of power supply wires which are lose and tie down all wires so they do not interfere with the mechanical operation of the recorder.

STEP 11 Replace the side panels on the recorder and hold them in place with the six screws numbered 11 through 16 in Figure 4-1.

STEP 12 Replace the bottom screen and fasten with the eight screws numbered 1 through 8 in Figures 4-1 and 4-2.

2.3.4 Continued

STEP 13 Replace the case top by engaging the left-hand hinge pin, grasping the rear edge of the right-hand side piece, and springing the side piece away from the recorder so it will engage the right-hand hinge pin. See Figure 2-1.

STEP 14 Install the event marker pen on the pen assembly. See Figure 2-16.

STEP 15 For the left-hand event marker, remove screw A in Figure 2-1 and fasten the ink cartridge clip to the recorder using the nut, bolt, and washer provided in the kit.

STEP 16 For the right-hand event marker, use the ink cartridge clip on the pen lift solenoid assembly if it is present. See Figure 2-10. If the pen lift solenoid assembly is not present, install the ink cartridge clip for the right-hand event marker under the rear serve mounting plate screw. See Figure 2-9.

STEP 17 Attach one end of capillary ink tubing to the event marker pen assembly and the other end to the pierce and prime unit.

STEP 18 Insert the ink cartridge all the way onto the pierce and prime unit. DO NOT SQUEEZE THE CARTRIDGE; apply pressure only at the end opposite the end pierced by the unit. Place the cartridge and pierce and prime unit in the clip.

STEP 19 Attach a pen filler to the pen tip and draw on the plunger until ink appears in the pen filler tubing. Remove the pen filler and its tubing.

STEP 20 Bend the event marker pen as necessary to align with the recording pen. Also bend the lifting tab as necessary so that the event marker pen lifts when the manual pen lift lever is raised.

STEP 21 See paragraph 3.10.2 for event marker operating instructions.

### 2.3.5 Installation of Retransmitting Potentiometer

Follow the procedure given in paragraph 4.12 - Potentiometer Replacement. Note in Step 9 that the leads disconnected in Step 5 are to be connected to the potentiometer next to the servo mounting plate (standard feedback potentiometer). After phasing the feedback potentiometer, proceed as follows:

STEP 1. Route the leads from the retransmitting potentiometer to receptacle connector J406 mounted at the rear of the recorder adjacent to the fuse holder.

STEP 2. Solder the leads to any available pins from A through J on J406.

STEP 3. The retransmitting potentiometer is shipped in phase with the feedback potentiometer. The retransmitter can be rephased by loosening the clamp band between the potentiometer sections and rotating the housing of the retransmitter while holding the feedback potentiometer firmly.

STEP 4. Reassemble the recorder, reversing the procedure given in paragraph 4.7.2.

### 2.3.6 Installation of Z-fold Chart Paper Holder

Remove recorder pen, event marker pen(s), and ink cartridge(s). A package containing two clips will be found in the Z-fold paper holder. These clips are used to keep the recorder in position on the holder.

STEP 1. Turn the recorder onto its left-hand side. Referring to Figure 4-1, remove screw No. 15. Mount one clip in this position so the tab faces the front, outside edge of the recorder. Insert the screw through the hole in the clip which is closer to the tab and tighten the screw.

STEP 2. Referring to Figure 4-1, remove screw No. 1. Retain the lock washer but discard the flat washer under the screw. Mount the other clip in this position so the tab faces the rear, outside of the recorder. Insert the screw through the hole in the clip which is farther from the tab, then through the lockwasher, and tighten the screw.

STEP 3. Place the recorder on the Z-fold holder so that the side frames of the recorder are positioned outside the rails on the holder. The clips attached in Steps 1 and 2 will prevent the recorder from sliding off the holder.

2.3.6 Continued

STEP 4. Place the chart paper in the removable tray inside the Z-fold holder. The top sheet of the chart paper should read "199 sheets left" (or "799 sheets left") and the round sprocket holes should be at the left.

STEP 5. Place the end of the chart paper under the tear-off bar and under the platen. Raise the platen and insert the end of the chart paper under the sprocket drum, aligning the sprocket holes with sprockets on the drum.

STEP 6. Raise the paper hold-down clips, lower the platen, and rotate the paper advance knob to bring the paper over the platen.

STEP 7. Lower the paper hold-down clips.

STEP 8. Push the tray containing the paper to the rear of the Z-fold holder so that 7 inches remains at the front of the holder to collect the recorded chart.

STEP 9. Push the drawer into the Z-fold holder until a 1/2-inch gap remains between the top of the tray and the holder.

STEP 10. Advance the chart over the tear-off bar and check that the paper withdraws smoothly from the tray and stacks properly in the holder.

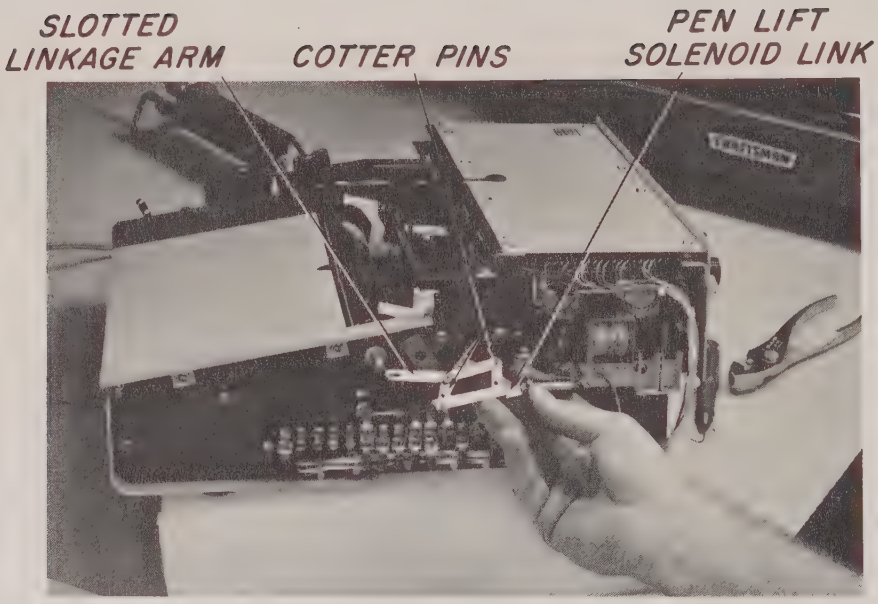



Figure 2-11. Pen Lift Solenoid Linkage Assembled

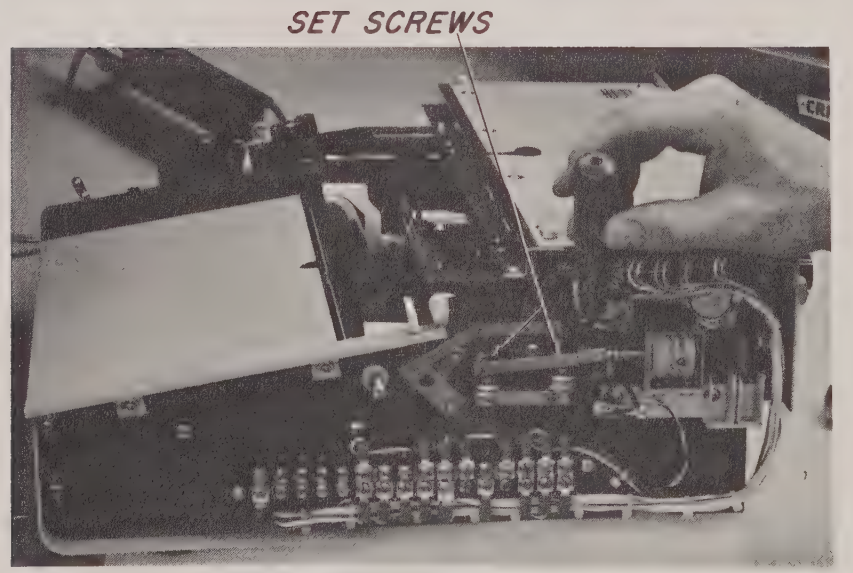



Figure 2-12. Pen Lift Solenoid Linkage Installed

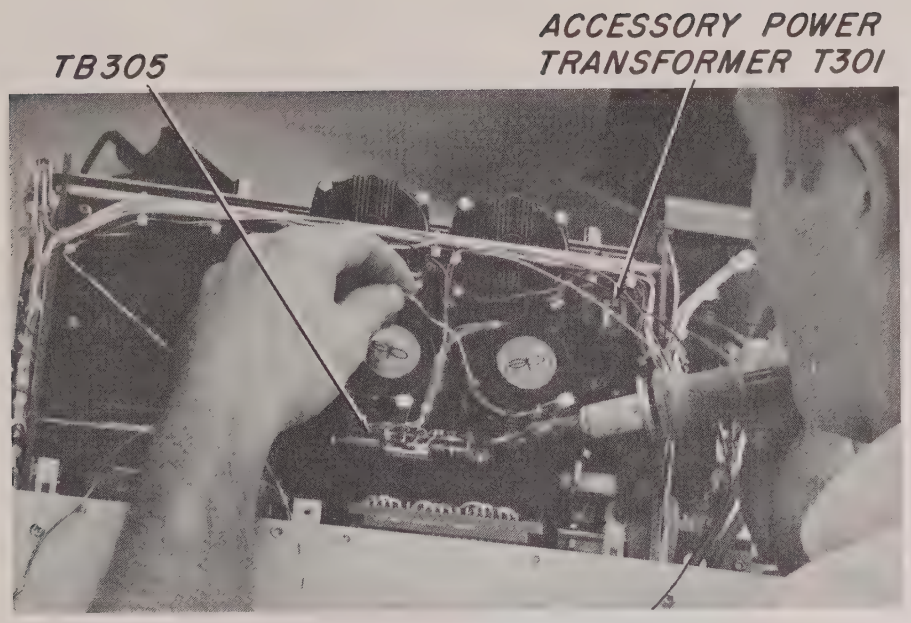



Figure 2-13. Connecting Wires to TB305

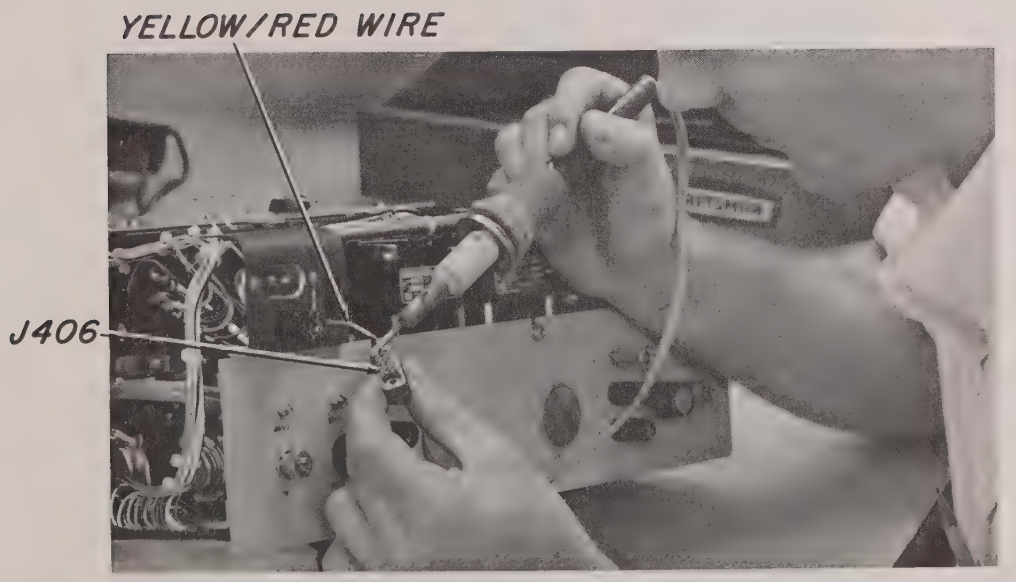



Figure 2-14. Connecting Wires to J406

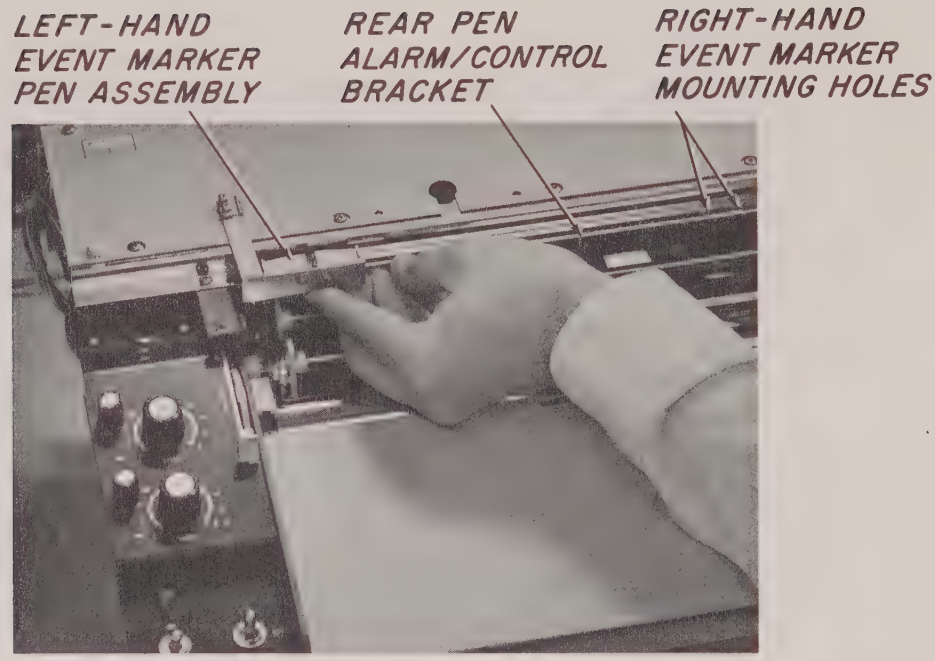



Figure 2-15. Installation of Event Marker Pen Assembly

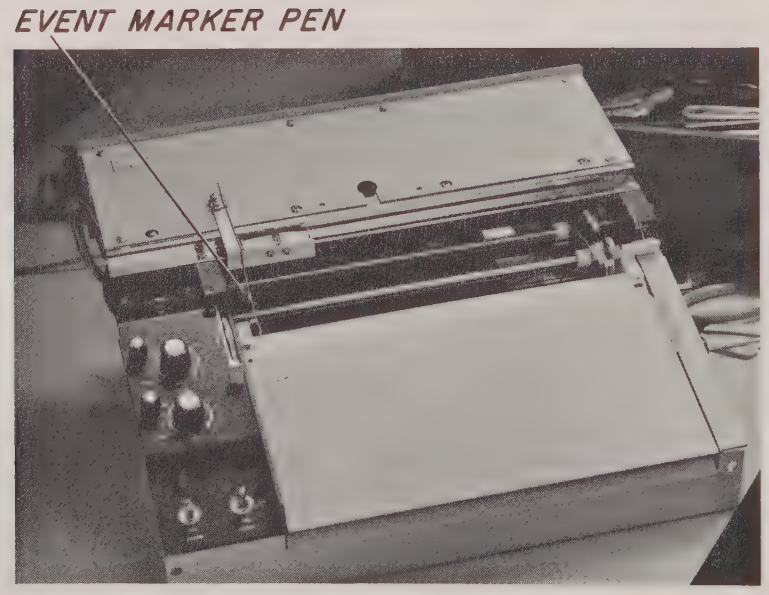



Figure 2-16. Location of Event Marker Pen

# SECTION 3
# OPERATION

## 3.1 GENERAL

All operating controls and adjustments are located on the control panel or at the rear of the recorder. Both chart paper loading and ink cartridge installation are extremely simple procedures. Standard chart paper comes in rolls approximately 120 feet long. The number of feet remaining in the roll is marked at one foot intervals on the left-hand margin of the paper. A specially-formulated ink comes in cartridge form.

## 3.2 INSTALLATION OF CHART PAPER

STEP 1. Raise the pen lift-paper guide into its up position.

STEP 2. Push the release lever and rotate the RATIO control half way between stops to disengage gears.

STEP 3. Raise the platen and place a roll of chart paper on the flat portion of the paper chute so that the roll rests against the under side of the platen. Be sure that the round sprocket holes are at the left, and oblong holes are at the right.

STEP 4. Holding the roll in place, unwind about 8 inches of paper.

STEP 5. Feed the end of the paper under the sprocket drum. Turn the paper advance knob to pull the chart paper around the sprocket drum. Be sure the holes at either side of the chart paper are engaged with sprockets and that the paper is properly aligned.

STEP 6. Place the roll in the paper chute and lower the platen.

STEP 7. Lower the pen lift-paper guide.

STEP 8. Using the paper advance knob, advance the chart paper over the platen and feed the paper through the slot between the platen and the paper tear bar.

3.2 Continued

STEP 9. Re-engage chart drive gears by rotating the RATIO control to a stop position.

STEP 10. Attach the chart-weight clip to the end of the chart paper at its center.

3.3 INSTALLATION OF PEN ASSEMBLY AND INK CARTRIDGE - MAIN RECORDER PEN(S)

STEP 1. As an aid to installing an ink cartridge, the indented end of the cartridge may be carefully pre-punched with a sharp object. This procedure is optional.

STEP 2. Holding the pen assembly in its normal upright position (do not cover the vent tube with finger), insert the ink cartridge all the way onto the pen assembly. DO NOT SQUEEZE THE CARTRIDGE; apply pressure only at the end opposite the end pierced by the pen.

STEP 3. Clip the pen assembly over the pen bearing. Be sure the guide pin engages the slot in the pen bearing. For correct pen alignment, push the pen assembly snug against the stop at the right-hand side of the pen bearing.

STEP 4. With plastic tubing supplied, attach a pen filler to the pen tip and draw on the plunger until ink barely appears in the tubing. Remove the pen filler and tubing.

STEP 5. To remove the pen assembly (for replacement of the ink cartridge), simply slide the assembly off the left-hand end of the pen bearing.

3.4 INSTALLATION OF INK CARTRIDGES - EVENT MARKER PEN(S)

Follow Steps 17, 18, and 19 of paragraph 2.3.4.

3.5 PRIMARY POWER REQUIREMENTS

Recorders are shipped ready for operation from a primary power source of 115 or 230 vac, 60 or 50 Hz. Each recorder comes equipped with a 3-conductor power cable terminated with a standard power plug. A plate mounted on the rear of the recorder indicates power specifications for the recorder.

## 3.6 SIGNAL SOURCE CONNECTIONS

The red, black, and silver binding posts at the rear of the recorder are used to connect signal voltages to be monitored. The red post is the high potential (+) terminal, the black post is the low potential (-) or signal ground terminal, and the silver post is the chassis ground terminal. These terminals should be used as required by the circuit configuration that produces the voltage to be monitored. Under standard polarity conditions, a positive-going signal applied to the red binding post will move the pen from left to right. See paragraph 1.5.7 for information on reversed polarity circuitry.

## 3.7 CONTROLS AND CALIBRATION ADJUSTMENTS

### 3.7.1 Power Control

The POWER switch (ON-OFF), located on the control panel, controls ac power to the recorder. In the ON position, the indicator lamp will light, the servo amplifier(s) will operate and the pen(s) will respond to input signals. At this time, power is applied to the CHART switch for energizing the chart drive motors. A short time will be required before the power supply voltages stabilize. In the OFF position, the power switch removes power from the recorder.

### 3.7.2 Chart Drive Control

The CHART switch (HI, OFF, LOW), located on the control panel, controls power to the chart drive motor(s) when the POWER switch is ON. A decal indicating chart speed(s) is located under the hinged top. The ON-OFF switch for the optional integrator is connected so that the integrator may be operated when the CHART switch is in either the LOW or HI position, or the integrator may be turned off completely. Power is furnished to event markers only when the CHART switch is in either the LOW or HI position. The accessory Electric Pen Lift is connected through the CHART switch so that the recorder pen automatically raises when the CHART switch is OFF and lowers when the CHART switch is in either the LOW or HI position.

### 3.7.3 Span Control

Multiple span recorders have 10-position rotary switches for selection of the desired span. Calibrated spans are 1, 2, 5, 10, 20, 50, 100, 200, 500 millivolts, and 1 volt. The variable attenuator (VAR ATTEN) control, located adjacent to the SPAN switch, operates switch S502 and variable resistor R505. Switch S502 is open in the CCW position (CAL) of the control; R505 provides continuous adjustment of input signal level from 100% to 20% of the full scale value selected by the SPAN switch when S502 is closed.

3.7.3 Continued

The span element on single-span recorders may be exchanged for another element simply by withdrawing the unit and inserting the other element. If necessary, the procedures given in paragraph 4.8 may be followed to calibrate the recorder for the new span value.

3.7.4 Zero Adjustment

The ZERO control is located at the rear of the recorder. This control permits the operator to position the pen tip precisely at the desired zero position on the chart when the signal input terminals are shorted together. Full scale zero adjustment and one full scale width of zero suppression are provided on Series G-2000 recorders.

3.7.5 Calibration Adjustments

Damping (DAMP), gain (GAIN), and calibration (CAL) adjustments are located at the rear of the recorder and need no adjustment during normal operation.

3.8 MODES OF OPERATION

3.8.1 Single Channel Recorders

The various calibration adjustments of the recorder can be set as detailed in paragraph 4.8 to obtain the (1) left margin zero, (2) right margin zero, (3) displaced zero, or (4) suppressed zero mode of operation described below. Note that when an integrator is installed, 0.8 inch of the 10-inch chart is required for the right-hand margin integrator trace.

3.8.1.1 Left Margin Zero Mode

In the left margin zero mode of operation, the ZERO control is set so that the pen is positioned over the left margin of the chart paper when the signal input terminals are shorted. The pen is driven toward the right margin when a positive dc input signal voltage is applied. The adjustment can be set so that the right margin represents a voltage between 1 millivolt and 1 volt, depending on the span selected. The linear scale across the top of the recorder can be used to determine the value of each intermediate point on the chart paper when the left margin represents zero volts and the right margin represents some voltage between 1 millivolt and 1 volt.

### 3.8.1.2 Right Margin Zero Mode

In the right margin zero mode of operation, the ZERO control is set so that the pen is positioned over the right margin of the chart paper when the signal input terminals are shorted. The pen is driven toward the left margin when a negative dc input signal voltage is applied. The adjustment can be set so that the left margin represents a voltage between 1 millivolt and 1 volt, depending on the span selected. The linear scale across the top of the recorder can be used to determine the value of each intermediate point on the chart paper when the right margin represents zero volts and the left margin represents some voltage between 1 millivolt and 1 volt.

With reversed polarity circuitry (see paragraph 1.5.7), positive dc voltages will drive the pen to the left.

### 3.8.1.3 Displaced Zero Mode

The ZERO control can be set so that any point on the chart paper represents zero signal voltage. If any point except the left or right margin is used, the recorder is considered to be in a displaced zero mode of operation. In this mode, a positive input voltage drives the pen to the right and a negative input voltage drives the pen to the left. The VAR ATTEN control can be set so that the numerical (not algebraic) sum of the voltages is equal to the full scale voltage selected. The linear scale across the top of the recorder can be used to determine the value of each point on the chart paper.

EXAMPLE

If the calibration adjustments are set so that the pen comes to rest at the numeral 4 on a 0-10 scale with zero signal volts applied and at the numeral 10 with 6 millivolts applied, an input signal that drives the pen to the numeral 2 has a negative polarity and an amplitude of 2 millivolts.

### 3.8.1.4 Suppressed Zero Mode

In the suppressed zero mode, no point on the chart paper represents zero input signal. The left- and right-hand margins both represent voltages of a positive polarity that differ in amplitude. The difference in amplitude is determined by the setting of the CAL adjustment.

3.8.1.4 Continued

EXAMPLE

If the procedure in paragraphs 4.8.1 through 4.8.3 were followed so that the left margin represented zero signal and the right margin represented +50 millivolts, the procedure in paragraph 4.8.5 could be used to make the left margin represent +20 millivolts. This would automatically make the right margin represent +70 millivolts. Note that these procedures apply only to positive voltages and that the span remains the same (50 millivolts) but the end points are shifted (from zero to +20 millivolts and +50 to +70 millivolts) an equal amount in the same direction.

3.8.2 Dual Channel Recorders

Any of the modes of operation described under paragraph 3.8.1 can be applied to both pens in dual channel recorders. Note that with the side-by-side pen system, the span for each channel is essentially 5 inches. When an integrator is installed, 0.8 inch of right-hand chart margin is required for the integrator trace.

3.9 ELECTRICAL INSPECTION

The following instructions should be followed for single channel recorders and for both channels of dual channel recorders. If an electrical or mechanical failure occurs during this inspection, refer to paragraph 4.6.2 and perform a detailed physical inspection of the recorder.

STEP 1. Turn the POWER switch to OFF.

STEP 2. Turn the CHART switch to OFF.

STEP 3. Install a roll of the proper chart paper. See paragraph 3.2.

3.9 Continued

STEP 4. Install pen assembly and ink cartridge. See paragraph 3.3.

STEP 5. BE SURE THE RECORDER AND ANY AUXILIARY EQUIPMENT ARE CONNECTED TO EARTH GROUND. The ground wire of the 3-wire power cord and the silver binding post(s) (chassis ground) are internally connected. Thus, a 3-wire power cord automatically connects the recorder to earth ground when plugged into a grounded 3-wire power system. However, in the absence of this type of system, the recorder chassis and any auxiliary equipment MUST be connected to earth ground by means of an additional wire.

STEP 6. Short the red (+) and black (-) signal input terminals together.

STEP 7. On multiple span recorders, rotate the SPAN switch fully CW to the 1 volt position and the VAR ATTEN switch fully CCW to the CAL position, checking that both switches operate properly.

STEP 8. Connect the power cord to a proper source of power.

STEP 9. Turn the POWER switch to ON and observe that the indicator lamp is lit.

> NOTE
>
> If the indicator lamp does not light, check the fuse at the rear of the recorder and replace if necessary.

The pen will not respond instantaneously when the POWER switch is turned ON. Approximately 5 to 10 seconds are required for the amplifier voltages to stabilize and produce pen movement.

STEP 10. Rotate the ZERO control until the pen tip is aligned with the point on the chart paper that is to represent zero input signal.

3.9 Continued

STEP 11. Test all positions of the RATIO control. DO NOT attempt to rotate the RATIO control unless power is ON. The release lever must be pushed toward the rear of the recorder to disengage gears. Turn the CHART switch to LOW and observe that the chart paper moves smoothly. Repeat with the CHART switch turned to HI if two chart drive motors are installed.

> NOTE
>
> With very slow chart speeds, be sure sufficient time is allowed to determine that the paper actually is moving.

STEP 12. On multiple span recorders, rotate the SPAN switch to any desired setting.

STEP 13. Remove the short from the signal input terminals. Connect a dc voltage between the same terminals corresponding to the SPAN switch setting, or, with single-span recorders, to the voltage rating of the plug-in element. Observe that the pen moves to the point on the chart paper that represents the full scale voltage value.

STEP 14. Remove the dc voltage from the signal input terminals. Short these terminals and observe that the pen returns to the zero input signal position.

> NOTE
>
> The recorder is completely calibrated before shipment in accordance with the requirements specified. The calibration can be checked or changed as described in paragraph 4.8 of this manual.

STEP 15. Turn the CHART switch to OFF.

## 3.10 RECORDER OPERATION

### 3.10.1 Detailed Operating Instructions

STEP 1. Check supply of chart paper and ink.

STEP 2. Connect the power cord to an ac power source. BE SURE THE RECORDER IS PROPERLY GROUNDED. See Step 5, paragraph 3.9.

STEP 3. Turn the POWER switch ON. The pen will not respond instantaneously when the POWER switch is turned ON. Approximately 5 to 10 seconds are required for the amplifier voltages to stabilize and produce pen movement.

STEP 4. Short the red (+) and black (-) input terminals together.

STEP 5. Using the ZERO control, place the pen(s) at the desired position(s).

STEP 6. On multiple span recorders, set the SPAN switch and the VAR ATTEN control in positions corresponding to the maximum voltage to be monitored.

STEP 7. On single-span recorders, check that the rating of the plug-in element corresponds to the maximum voltage to be monitored.

STEP 8. Remove the short across the input terminals and apply the input signal to be monitored.

STEP 9. Select the chart speed desired, placing the CHART switch in either the LOW or HI position and rotating the RATIO control to the appropriate position. A table showing chart speeds vs RATIO control positions is located on the top shield under the hinged top.

STEP 10. To tear off chart paper, pull upward on the paper using the paper tear bar as a knife edge.

### 3.10.2 Event Marker Operation

To operate event markers, an external contact closure must be provided between designated pins on plug connector P406, the multipin mating connector for receptacle connector J406 mounted on the rear of the recorder. See the Wiring Diagram in Section 6. The following table shows the correct connections for the four modes of event marker operation:

3.10.2 Continued

| Event Marker | Deflection | Connect between pins |
|---|---|---|
| Left-hand | Left | P and K |
| Left-hand | Right | P and L |
| Right-hand | Left | P and M |
| Right-hand | Right | P and N |

## 3.11 OPERATING REMARKS AND RECOMMENDATIONS

The presence of voltages of power-line frequency at the recorder input may result in impaired recorder performance. The following describes one method of reducing the effects of ac voltage at the input.

AC voltages may be picked up by wires connecting the input signal source to the recorder, especially if the signal source has high internal resistance. These undesirable ac voltages may be eliminated by using shielded wires to connect the input signal source to the recorder. If shielded wires are used, the shield should be grounded only at the ground terminal of the recorder. Grounding both ends of the shield can produce ground loops. Most low-resistance sources will not require shielding. Simple twisted-pair leads will usually be satisfactory.

Series G-2000 recorders may be operated with a steady dc potential of $\pm$200 volts maximum between chassis ground and the input signal.

# SECTION 4
# SERVICE AND MAINTENANCE

## 4.1 GENERAL

Service and maintenance of Series G-2000 recorders should be performed only by persons experienced in servicing electromechanical devices having transistorized circuitry. If no such person is available, the recorder should be sent to the factory, or to a factory representative, for service.

## 4.2 FIELD AND FACTORY SERVICE

Please get in touch with the Recorder Division Service Manager prior to returning any equipment to the factory, to determine the service needed. Should it become necessary to return an instrument for service, please observe the following:

1. Remove pens, ink cartridges, chart paper, dust cover, and power cord; do not send with equipment.

2. Rinse out any capillary tubing with water.

3. The original shipping container or another suitable container should be used and the recorder should be surrounded on all six sides by about 4 inches of packing material.

4. Recorders should be shipped by Railway Express, air freight, or motor freight, PREPAID, to the nearest Varian Associates Recorder Sales Representative, or to:

   *Varian Aerograph*
   *2700 Mitchell Drive*
   *Walnut Creek, California 94598*

   *Attention: Recorder Division*
   *Service Manager*

5. Each recorder should be accompanied by a full description of difficulties encountered, model and serial number of recorder, date of purchase, and name of representative from whom the recorder was purchased.

4.2 Continued

> NOTE
>
> Varian Associates has an established policy that equipment sent in for service will be completely checked in addition to correcting the cause of the malfunction. Equipment shipped to the user will meet the specifications under which it was originally sold. When it appears that it will be unusually expensive to bring an out of warranty instrument up to specifications, the user will be contacted for specific instructions.

## 4.3 PREVENTIVE MAINTENANCE

### 4.3.1 Pens

Recorder pens must be kept clean for proper functioning. Inks are water-soluble. For cleaning, water should be forced through the pen system. Cold water is normally satisfactory, but if the pen is obstructed liquid detergent in warm water may be used and a piece of pen cleaning wire may be drawn through the pen system to dislodge the obstruction. The pen filler furnished with the recorder may be used as an aid in cleaning the pen. A small piece of plastic tubing installed between the pen filler and the pen tip may be used as a connection when drawing or feeding water through the pen. To assure maximum performance, pens should always be cleaned immediately after use.

### 4.3.2 Carriage Rods

To maintain smooth operation of the pen carriage(s), the carriage rods must be kept clean. Be sure to clean the rod if ink should accidently be spilled onto it. Periodically, clean the carriage rods with a dry, lint-free cloth. DO NOT OIL THESE RODS.

## 4.4 LUBRICATION

Only the servo motor(s) in Series G-2000 recorders require lubrication, at three month intervals. Place one or two drops of motor oil (furnished with the recorder) in each of the red-painted holes in the servo motor(s). DO NOT OVER-LUBRICATE. A pen filler can be used for transferring the oil. The tip of the pen filler is inserted through convenient holes in the rear screen.

## 4.5 SOLID STATE CIRCUITRY TECHNIQUES AND PRECAUTIONS

### 4.5.1 Introduction

Modern semiconductor circuits use a variety of elements ranging from simple diodes through integrated circuits. Between the two extremes is an array of elements such as junction Field Effect Transistors (FETs), Metal Oxide Silicon Field Effect Transistors (MOSFETs), and bipolar transistors. Each element of the semiconductor family (with perhaps the exception of the diode) may introduce certain restrictions on troubleshooting techniques which, if not observed, can result in the destruction of the device under test. The following discussion summarizes some of the basic precautions to be observed when troubleshooting semiconductor circuits in the G-2000 series of recorders. Some differences between types of elements are also pointed out. Note that emphasis is directed towards silicon devices rather than germanium since the use of silicon is more prevalent.

### 4.5.2 General Precautions

#### 4.5.2.1 Soldering

Excessive heat from improper soldering techniques can easily destroy or impair the operating characteristics of a semiconductor device. In general, if the soldering point is about 1/8" from the body of the device, the maximum time to temperature relationship is about 260°C for 10 seconds. Relating this to a soldering instrument is difficult; however, the following guide lines have been found to be valid.

For a 150 watt soldering gun, the maximum time of contact 1/8" from body is approximately 6 seconds. For a 40 watt soldering iron, the maximum time of contact 1/8" from body is approximately 30 seconds.

It is apparent from the foregoing that in order to stay within the time to temperature limitations (1) the leads to be soldered should be pre-tinned, and (2) the terminal joint should be thoroughly cleaned.

Some types of soldering irons have a failure mode in which one side of the ac line can become shorted to the soldering tip.

4.5.2.1 Continued

To eliminate the possibility of circuit damage under this type of condition it is always desirable to (1) operate a soldering iron from an isolation transformer, and (2) remove the ac connection of the equipment under repair.

4.5.3 Troubleshooting

Troubleshooting techniques vary with the type of circuit and the type of semiconductor device utilized. In general linear circuits lend themselves to voltage and resistance type measurements.

Voltage and resistance measurements can normally be made by a battery-operated multimeter. A VTVM type is desirable in order to obtain a high input impedance on low voltage ranges. Care must be exercised on resistance checks in that some types of meters apply voltages in the order of 45 volts (on the higher resistance scales) to the circuit under test. This voltage is of sufficient magnitude to cause junction breakdown in many transistors and, if the current is not limited, destroy the device. The best selection is a meter operating from a low voltage (less than 3 volts) on all resistance scales.

4.5.3.1 Linear Circuits

Bipolar Transistors. In linear circuits using bipolar transistors, two simple voltage checks can be made under static (power on, no signal applied) conditions to help isolate a source of trouble. These are as follows:

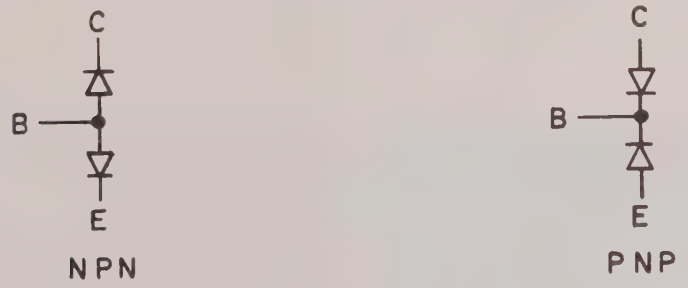
(1) $V_{BE}$, the forward base-emitter voltage, will usually be between 0.5 and 0.7 volt for most silicon transistors. For germanium, this voltage will be less than 0.3 volt. If the $V_{BE}$ reading is significantly larger than this, the junction is either open or not terminated. A significantly lower reading would indicate either a shorted junction or insufficient source voltage.

(2) $V_{CE}$ is the collector-emitter voltage. The normal operating point for $V_{CE}$ in a linear circuit is usually well above the $V_{sat}$ (saturating voltage) level. $V_{sat}$ is usually less than 0.3 volt. If a $V_{CE}$ reading indicates a voltage lower than would be expected from the circuit configuration, a jumper connected between base and emitter should cause the $V_{CE}$ reading to increase. If not, either the collector-emitter junction is shorted or the collector is shorted by its load.

If either of the above voltage checks indicates a possible defective device, further testing can be done in the circuit (with power OFF) on individual

4.5.3.1 Continued

devices by making continuity checks across the transistor junctions. For the purposes of this check, the transistor can be represented as a pair of diodes connected as shown below:




Diode Representation of Transistor for Continuity Check

Measuring across the junction will indicate a low resistance in one direction and a higher resistance (determined by external circuitry) in the other direction with either a collector-base or base-emitter diode. When measuring resistance between collector and emitter on small signal transistors, the reading should be high in both directions. On power devices however, the collector-emitter resistance reading can be misleading due to leakage currents and caution should be exercised before rejecting a power device solely on the results of a collector-emitter continuity check.

4.5.3.2 Conclusion

To troubleshoot a solid state circuit successfully, it is first necessary to determine what the normal conditions should be. These conditions vary quite widely depending on what type of device is utilized. The above discussion is an attempt to summarize some of the more obvious problems involved in trouble-shooting and is not meant to educate or to cover all of the problem areas.

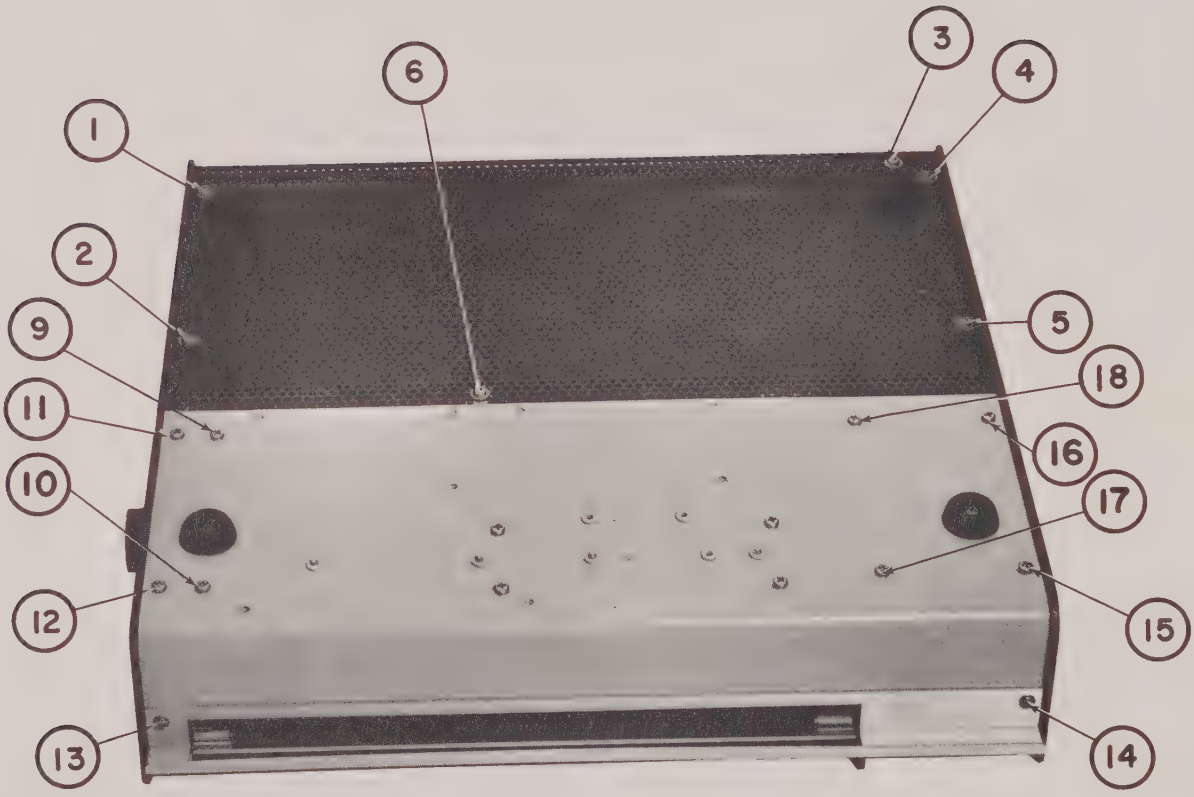



**Figure 4-1.**

## 4.6 TROUBLESHOOTING

### 4.6.1 General

If the recorder does not function properly, proceed as follows:

Read Section 3 of this manual carefully. Determine that (1) the chart paper and ink were properly installed, (2) the recorder is connected to a proper source of primary power, (3) the signal inputs are properly connected to the recorder, and (4) the operating controls are in appropriate positions. Schematics and Wiring Diagram in Section 6 can be used as guides while troubleshooting.

### 4.6.2 Physical Inspection

Disassemble the recorder following the procedure given in paragraph 4.7. Thoroughly inspect the recorder. Among the points to be covered are the following:

a. Check that all assemblies and components are securely mounted.

b. Check that all connections to terminal boards, connectors, etc., are securely fastened.

c. Check that gears operate properly. A minimal backlash should exist between gears and idlers.

d. Check pen drive cabling for smooth operation.

### 4.6.3 Troubleshooting Chart

Following is a list of symptoms and possible causes of recorder malfunction:

TABLE II

Troubleshooting Chart

| Symptom | Possible Cause |
|---|---|
| Recorder fails to operate | Power cord not connected. Fuse open. |
| Chart paper does not advance | RATIO control gears disengaged. Fuse open. |
| Intermittent chart paper advance | Improper gear operation. |
| Pen moves to extreme limit of travel; servo motor continues to operate | Chopper defective. Input circuit open. |

| | |
|---|---|
| Large dead band, sluggish operation | Low amplifier gain. Stray ac pickup. Excessive source resistance. Low line voltage. Chopper defective. Bind in mechanical system. Excessive drive cable tension. Zener diodes defective. |
| Nonuniform pen velocity | Bind in mechanical system (pen carriage binding on rod). Excessive drive cable slack. Chopper defective. |
| Pen oscillates at any position of DAMP control | Excessive amplifier gain. Dirty potentiometer. Open damping control. |

4.6.3 Continued

| Symptom | Possible Cause |
|---|---|
| Repeated pen "jitter" at same point on chart | Dirty or worn feedback potentiometer. |
| Intermittent pen oscillation at various points on chart | Power line transients. Loose connection of signal cable. |
| Low or zero gain | Defective transistor. |
| Steady pen deflection to right or left | Chopper defective (bad contacts). Input circuit open. |
| No servo control; no signal response | Chopper defective (open winding). |
| Erratic pen movement | Feedback potentiometer defective. Power supply capacitors defective. |
| Loss of reference or amplifier supply voltage | Zener diodes defective. |
| Full span sweep across chart is curved or irregular | Bind in mechanical system. Shorted potentiometer windings. |
| Loss of calibration | Zener diodes defective. |

## 4.7 DISASSEMBLY

### 4.7.1 Partial Disassembly

To disassemble the recorder for only amplifier servicing and/or restringing pen drive cable, proceed as follows. Be sure the power cord, accessory plug, and signal leads are disconnected.

STEP 1. Remove pen(s), ink cartridge(s), and chart paper.

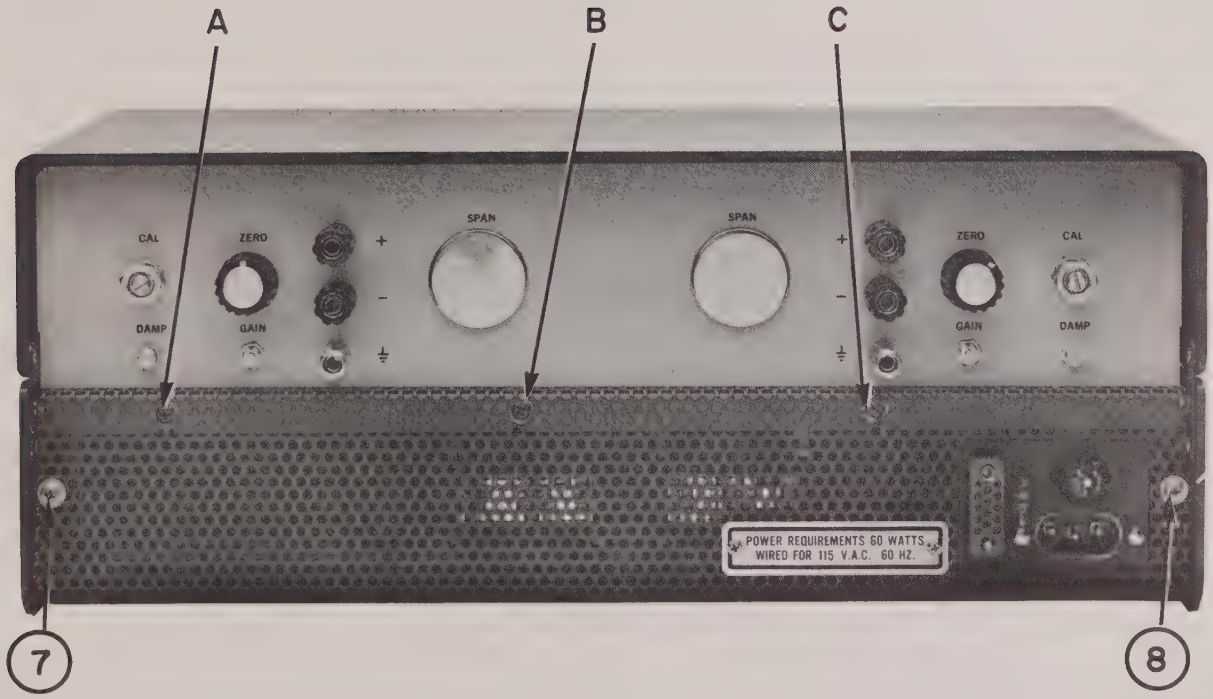

A
B
C
CAL
ZERO
GAIN
DAMP
SPAN
+
−
⏚
SPAN
+
−
⏚
ZERO
GAIN
CAL
DAMP
POWER REQUIREMENTS 60 WATTS
WIRED FOR 115 V.A.C. 60 HZ.
7
8

**Figure 4-2.**

STEP 2. To remove the case top (a) tilt top upward; (b) grasp it at the right-hand rear edge and spring the side piece out to the right, disengaging it from the hinge pin; (c) move it to the left, and disengage from the left-hand hinge pin.

STEP 3. Turn the recorder around so the technician is facing the rear of the recorder. With a Phillips screwdriver, loosen (do not remove) the three screws (A, B, and C) along the bottom of the input panel by inserting the screwdriver through the holes provided in the rear screen. See Figure 4-2.

4.7.1 Continued

STEP 4. Remove the two screws at either end of the rear alarm/control bracket. See Figure 2-1.

STEP 5. Unplug the Amphenol connector(s) from the amplifier printed circuit board(s). See Figure 4-3.

STEP 6. Lift the amplifier and rear panel assembly free of the recorder and place it on the bench in front of the technician. The amplifier is now available for servicing.

> W A R N I N G
>
> USE EXTREME CAUTION WHILE PERFORMING MAINTENANCE ON A DISASSEMBLED RECORDER SINCE PRIMARY POWER SWITCH TERMINALS ARE EXPOSED.

STEP 7. On dual channel recorders, remove the four screws in the motor shield. Stringing is now accessible.

STEP 8. To reassemble the recorder, reverse the above procedure.

4.7.2 Complete Disassembly

To disassemble the recorder for installation of accessories, amplifier servicing, restringing pen drive cable, potentiometer replacement, chart drive motor replacement or power supply servicing, proceed as follows. Be sure the power cord and signal leads are disconnected.

STEP 1. Follow Steps 1 and 2 of paragraph 4.7.1.

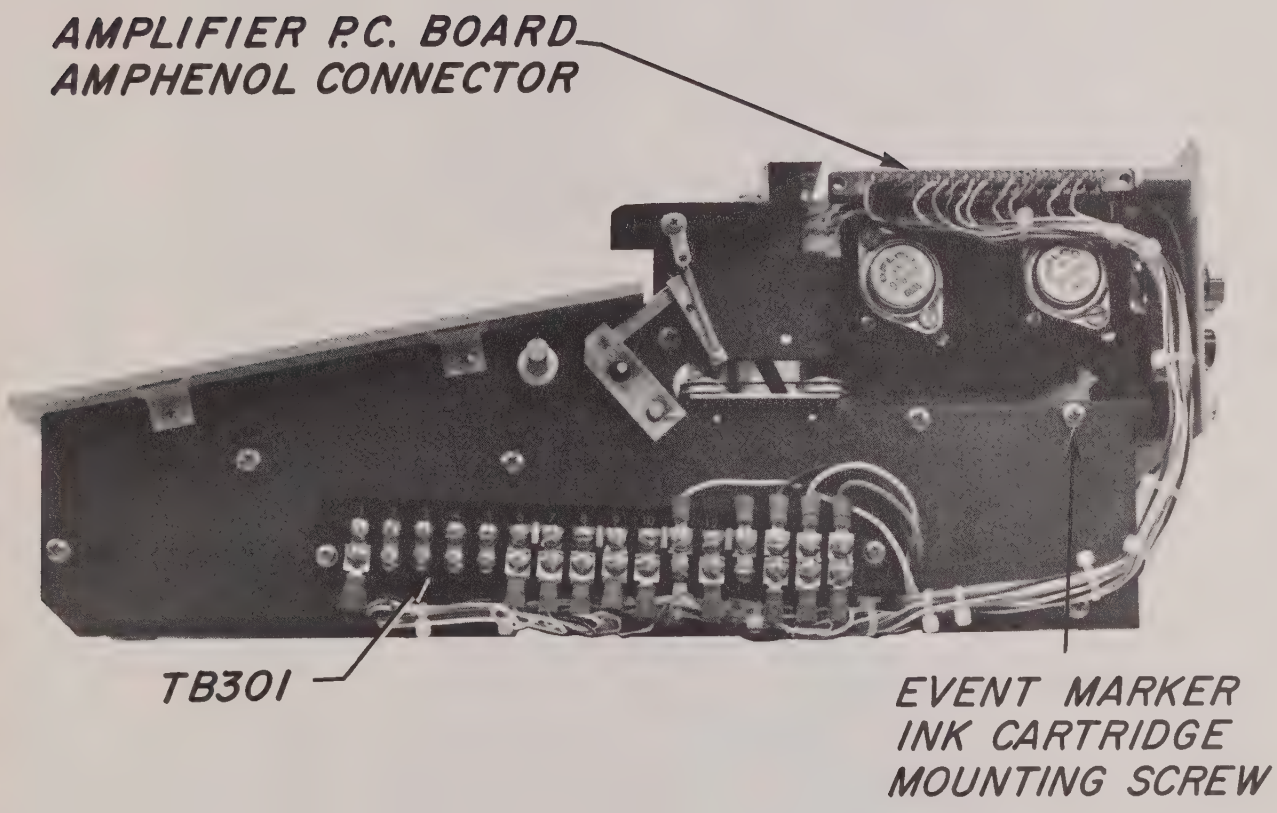

AMPLIFIER P.C. BOARD
AMPHENOL CONNECTOR
TB301
EVENT MARKER
INK CARTRIDGE
MOUNTING SCREW

Figure 4-3.

STEP 2. Turn the recorder upside down while holding the platen down.

STEP 3. Refer to Figures 4-1 and 4-2; remove the 8 screws indicated by numbers 1 through 8. Remove the bottom screen. (It is not necessary to remove the screws in the recorder feet). Chart drive motors can now be replaced.

STEP 4. Loosen two 6-32 set screws in the paper advance knob and remove the knob.

STEP 5. Refer to Figure 4-1; remove the 10 screws indicated by numbers 9 through 18 in the power supply assembly. The paper tear bar is removed and both side panels fall free.

STEP 6. Unplug the power supply connector(s) from the power supply printed circuit board(s). See Figure 4-4. The power supply assembly is now available for servicing.

> W A R N I N G
>
> USE EXTREME CAUTION WHILE PERFORMING MAINTENANCE ON A DISASSEMBLED RECORDER SINCE PRIMARY POWER SWITCH TERMINALS ARE EXPOSED.

STEP 7. Turn the recorder over and face the rear of the instrument. With a Phillips screwdriver, loosen (do not remove) the three screws along the bottom of the input panel.

STEP 8. Follow Steps 4 through 7 of paragraph 4.7.1. The amplifier is now available for servicing, stringing is accessible, and potentiometers may be replaced.

STEP 9. To reassemble the recorder, reverse the above procedure.

## 4.8 CALIBRATION

Series G-2000 recorders are completely calibrated before shipment. This procedure can be used to change the operating characteristics of the recorder or to restore the original characteristics after service.

STEP 1. Check that the recorder is supplied with chart paper, pen, and ink. If necessary, refer to Section 3 and replenish the paper and ink.

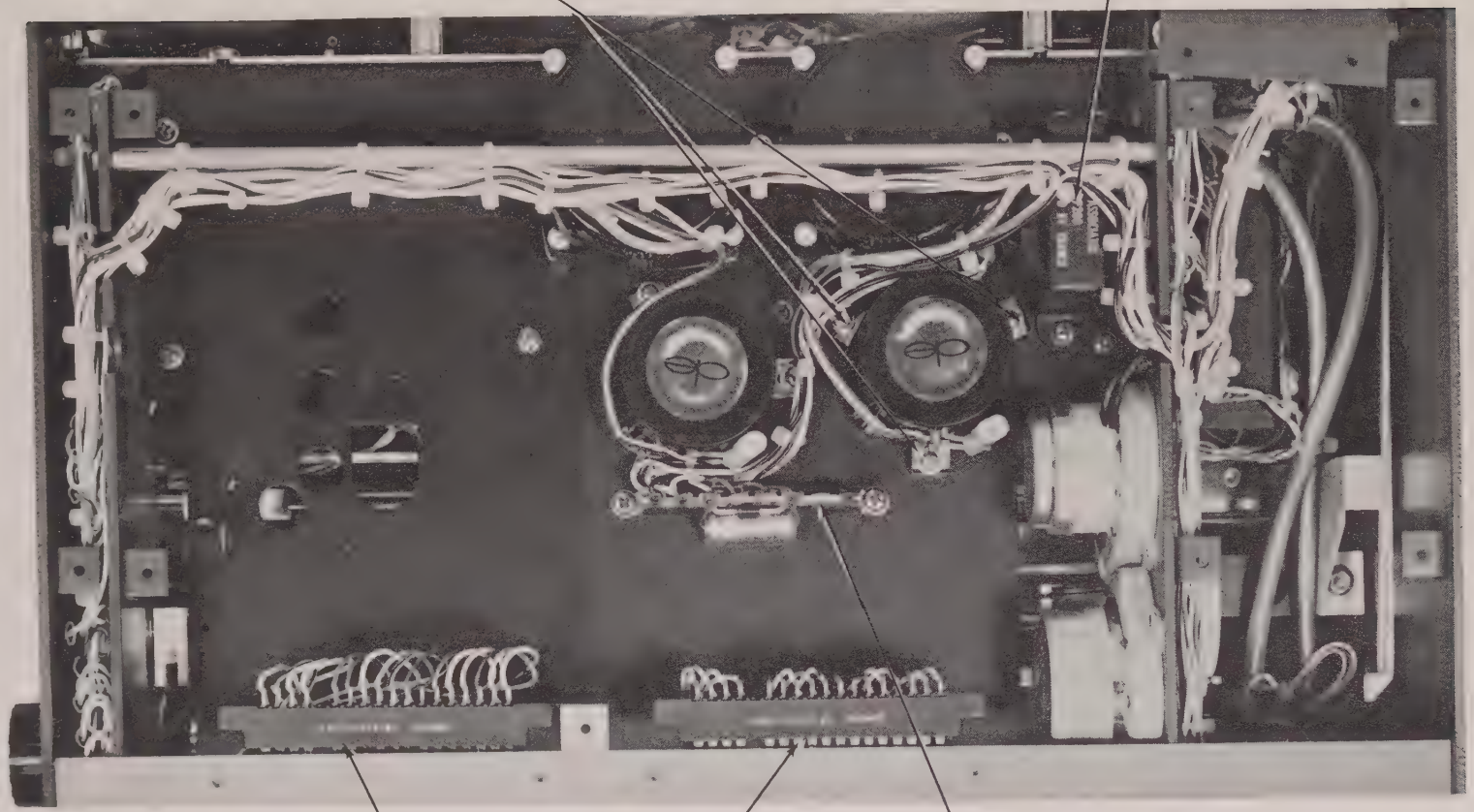

4-40 SCREWS AND CLAMPS
ACCESSORY POWER SUPPLY TRANSFORMER, T301
POWER SUPPLY CONNECTORS
ACCESSORY POWER SUPPLY TERMINAL BOARD ASSEMBLY, TB305

Figure 4-4

STEP 2. Connect the recorder to a proper source of power and turn the POWER switch to ON.

STEP 3. Set the CHART switch and RATIO control so that the chart paper is passing through the recorder at the rate of 1 inch per minute. If the recorder has non-standard chart speeds, select the speed which is nearest 1 inch per minute.

4.8.1 Zero Adjustment

STEP 1. Short the input terminals together (red to black).

STEP 2. On multiple span recorders, rotate the VAR ATTEN control fully CCW to the CAL position.

STEP 3. Set the ZERO control so that the pen is in exact alignment with the desired zero position on the chart paper. With standard polarity circuitry, this is usually near the left-hand margin. With reversed polarity (see paragraph 1.5.7), the zero position is usually near the right-hand margin of the chart paper.

4.8.2 Calibrate Adjustment

The CAL adjustment can be set as follows to provide full scale deflection of the pen assembly with a maximum input signal corresponding to the setting of the SPAN switch, or the voltage value of the plug-in span element.

STEP 1. Short the input terminals together and note that the pen is aligned with the zero position on the chart. Remove the short.

> NOTE
>
> If necessary, perform the Zero Adjustment procedure given in paragraph 4.8.1.

STEP 2. On multiple span recorders, set the SPAN switch at any desired position.

STEP 3. Connect a fixed dc voltage between the input terminals corresponding to the SPAN switch setting (or to the voltage value of the plug-in span element).

STEP 4. Rotate the CAL adjustment so that the pen is in exact alignment with the desired full scale position on the chart.

STEP 5. Disconnect the fixed dc voltage from the input terminals.

4.8.3 Gain and Damping Adjustments

The GAIN and DAMP adjustments of the recorder can be set as follows:

STEP 1. Short the signal input terminals together. Set the ZERO control so that the pen comes to rest at the center of the chart paper.

STEP 2. Turn the DAMP adjustment fully CW (maximum damping).

STEP 3. Remove the short from the signal input terminals and connect a dc voltage of an amplitude that will drive the pen less than half scale.

STEP 4. Short the input terminals and allow the pen to make a short trace on the paper.

STEP 5. Reverse the polarity of the voltage applied in Step 3; then momentarily remove the short connected in Step 4, allowing the pen to make a second short trace.

STEP 6. Determine the horizontal distance between the traces made in Steps 4 and 5. If it is greater than 20% of one small division of the chart paper (0.2% full scale), the GAIN adjustment should be turned slightly clockwise and Steps 3 through 5 should be repeated.

STEP 7. Disconnect the short from the signal input terminals and observe the trace made by the pen. Note that the pen does not overshoot the point on the chart paper at which it finally comes to rest.

STEP 8. Turn the DAMP adjustment slightly CCW, reconnect the short across the input terminals, then remove it again.

STEP 9. Observe the trace made on the chart paper. Repeat Step 8 until there is evidence of a small amount of overshoot; then, turn the DAMP adjustment slightly CW.

NOTE

The ideal trace (critical damping) forms a 90° angle where it changes from a horizontal to a vertical direction. Do not turn the DAMP adjustment so far as to round off this "corner."

4.8.3 Continued

STEP 10. Make the zero adjustment described in paragraph 4.8.1 and check the calibrate adjustment described in paragraph 4.8.2.

> NOTE
>
> If it is necessary to reset the CAL adjustment, repeat Steps 1 through 10, paragraph 4.8.3.

4.8.4 Displaced Zero Operation

The ZERO adjustment is set according to the procedure given in paragraph 4.8.1. For displaced zero operation, the zero position on the chart is other than the left-hand or right-hand margin.

4.8.5 Suppressed Zero Operation

The following calibration procedure can be used when suppressed zero operation is desired:

STEP 1. Follow the procedures given in paragraph 4.8.1 through 4.8.3.

STEP 2. Select an appropriate position of the SPAN switch, or insert a plug-in span element of appropriate voltage rating.

STEP 3. Connect to the signal input terminals a fixed dc voltage of the value to be represented by the zero position on the chart paper.

> NOTE
>
> Observe polarity of input terminals. This voltage must not exceed the full scale value of the span selected.

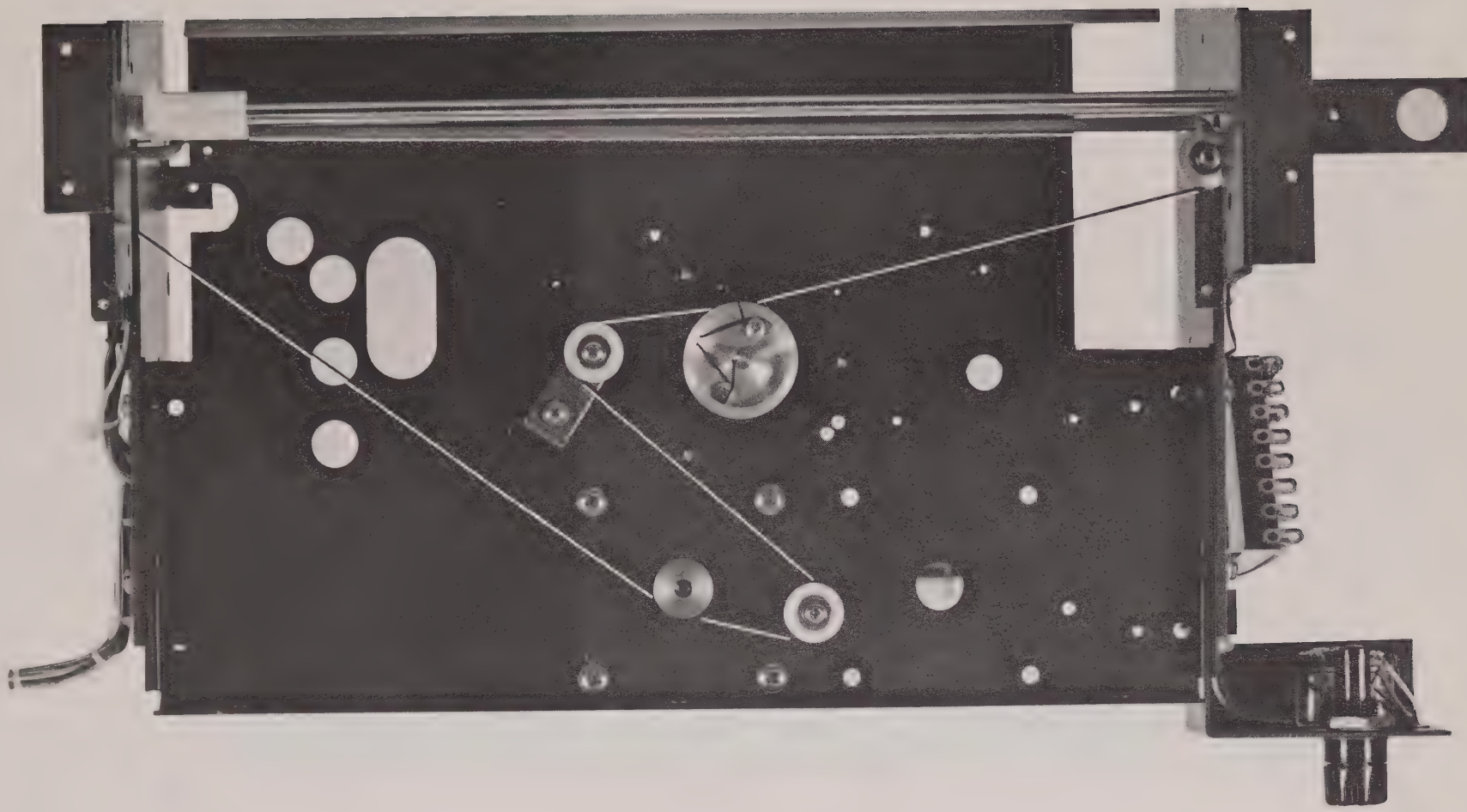


Figure 4-5

4.8.5 Continued

STEP 4. Set the ZERO control so that the pen is in exact alignment with the desired zero position on the chart paper.

STEP 5. Disconnect the fixed dc voltage from the input terminals.

## 4.9 RESTRINGING PEN DRIVE CABLE

Partially disassemble the recorder following the procedure of paragraph 4.7.1. The technician will now be facing the rear of the recorder; left-hand and right-hand orientation during this procedure is from this perspective. Remove old cable, if necessary.

### 4.9.1 Single Channel Recorders

Refer to Figure 4-5 which shows cable correctly strung.

STEP 1. Rotate the potentiometer sheave fully CCW. Be sure the hole in the sheave faces the front of the recorder (away from the technician). If it does not, loosen the set screw in the sheave, adjust the sheave position, and retighten the set screw.

STEP 2. Using a 60-inch length of cable, insert about 2 inches through the hole in the sheave. Wrap the cable 1 turn CW around the left-hand 4-40 screw inside the sheave and tighten the screw.

STEP 3. Wrap the cable 1/2 turn CCW around the spring-loaded idler pulley at the left of the potentiometer. Pull the cable taut enough so the pulley arm moves through a 120° arc.

STEP 4. Wrap 1/2 turn CW around the stationary idler pulley at the rear of the recorder.

STEP 5. Wrap 1 turn CW around the servo motor sheave.

STEP 6. Wrap 1/4 turn CW around the pulley on the bracket at the left-hand side of the recorder.

STEP 7. Slide the pen bearing to its extreme right-hand limit of travel.

STEP 8. Insert the cable through the slot in the pen bearing.

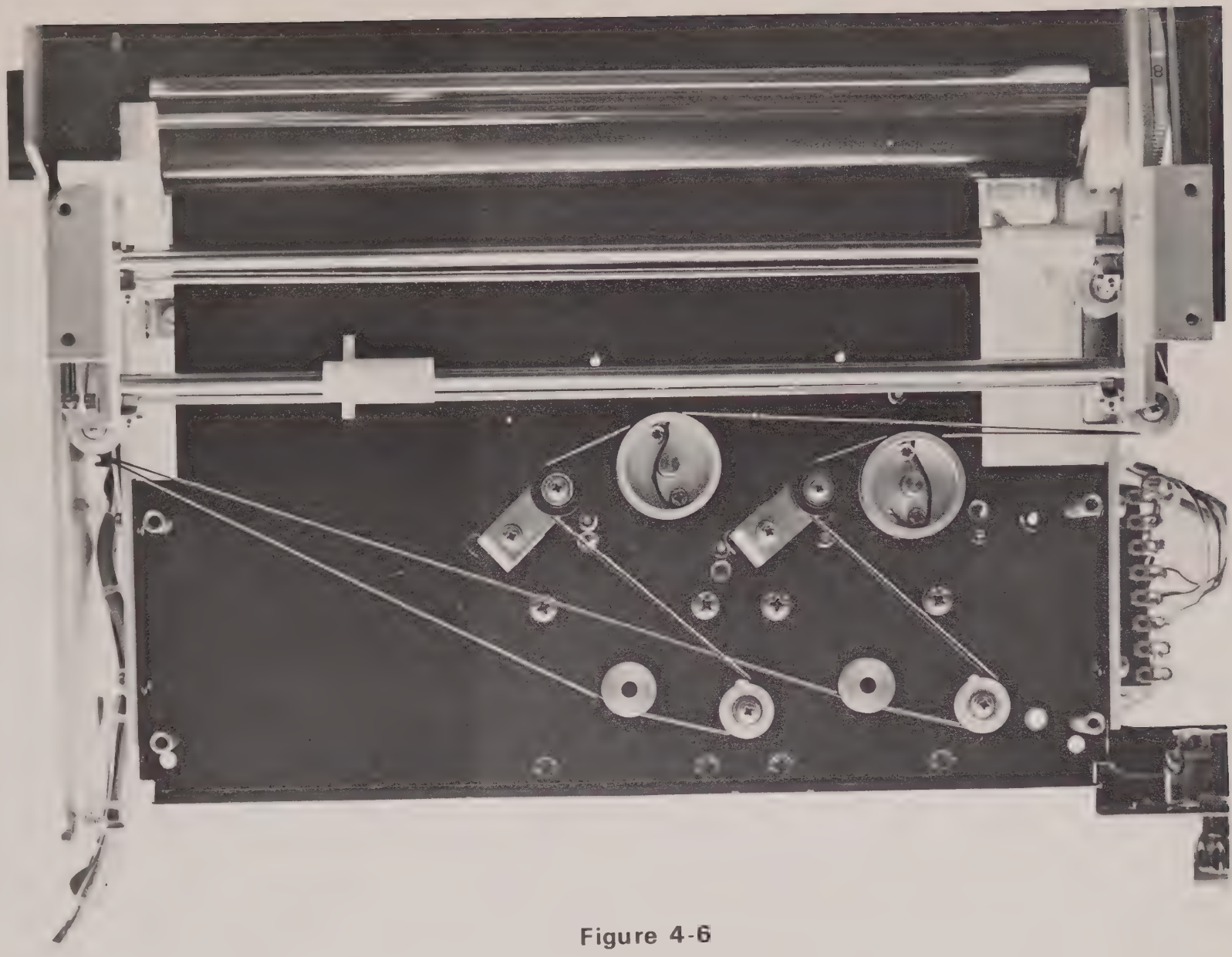


Figure 4-6

4.9.1 Continued

STEP 9. Loop the cable under the corner of the pen bearing and back through the slot. Repeat the loop to obtain two loops.

STEP 10. Wrap the cable 1/2 turn CW around the pulley on the bracket at the right-hand side of the recorder.

STEP 11. Holding the cable taut, rotate the potentiometer CW, wrapping the cable from the spring-loaded idler pulley around the sheave until the pen bearing reaches its full left-hand limit of travel. The cable must be aligned progressively UP the sheave.

STEP 12. Place the free end of the cable on the potentiometer sheave beneath the cable from the spring-loaded idler pulley and wrap the cable CCW around the potentiometer sheave to the hole. Insert the cable end through the hole. Wrap the cable 1 turn CW around the remaining 4-40 screw inside the sheave and tighten the screw.

STEP 13. Move the pen bearing back and forth to assure that the stringing system is operating smoothly. When the pen bearing moves from right to left, the cable from the spring-loaded idler pulley should wrap progressively UP the potentiometer sheave. When the pen bearing moves from left to right, the cable leaving the right-hand pulley should wrap progressively DOWN the potentiometer sheave.

STEP 14. Cut off excess cable, leaving approximately 1/2" inside the sheave.

STEP 15. Proceed to paragraph 4.10 for potentiometer phasing procedure.

4.9.2 Front Pen on Dual Channel Recorders

Refer to Figure 4-6 which shows cable correctly strung. On recorders having a side-by-side pen system, remove the stop temporarily from the front pen rod.

STEP 1. Rotate the potentiometer sheave fully CCW. Be sure the hole in the sheave faces the front of the recorder (away from the technician). If it does not, loosen the set screw in the sheave, adjust the sheave position, and retighten the set screw.

4.9.2 Continued

STEP 2. Using a 60-inch length of cable, insert about 2 inches through the hole in the sheave. Wrap the cable 1 turn CW around the left-hand 4-40 screw inside the sheave and tighten the screw.

STEP 3. Wrap the cable 1/2 turn CCW around the spring-loaded idler pulley at the left of the potentiometer. Pull the cable taut enough so the pulley arm moves through a $120^{o}$ arc.

STEP 4. Wrap 1/2 turn CW around the stationary idler pulley at the center rear of the recorder.

STEP 5. Wrap 1 turn CW around the left-hand servo motor sheave.

STEP 6. Wrap 1/4 turn CW around the lower rear pulley on the bracket at the left-hand side of the recorder.

STEP 7. Wrap 1/4 turn CW around the front pulley on the bracket at the left-hand side of the recorder.

STEP 8. Slide the pen bearing to its extreme right-hand limit of travel.

STEP 9. Insert the cable through the slot in the pen bearing.

STEP 10. Loop the cable under the corner of the pen bearing and back through the slot. Repeat the loop to obtain two loops.

STEP 11. Wrap the cable 1/4 turn CW around the front pulley on the bracket at the right-hand side of the recorder.

STEP 12. Wrap 1/4 turn CW around the lower rear pulley on the bracket at the right-hand side of the recorder.

STEP 13. Holding the cable taut, rotate the potentiometer CW, wrapping the cable from the spring-loaded idler pulley around the sheave until the pen bearing reaches its full left-hand limit of travel. The cable must be aligned progressively UP the sheave.

STEP 14. Place the free end of the cable on the potentiometer sheave beneath the cable from the spring-loaded idler pulley and wrap the cable CCW around the potentiometer sheave to the hole. Insert the cable end through the hole. Wrap the cable 1 turn CW around the remaining 4-40 screw inside the sheave and tighten the screw.

4.9.2 Continued

STEP 15. Move the pen bearing back and forth to assure that the stringing system is operating smoothly. When the pen bearing moves from right to left, the cable from the spring-loaded idler pulley should wrap progressively UP the potentiometer sheave. When the pen bearing moves from left to right, the cable leaving the right-hand pulley should wrap progressively DOWN the potentiometer sheave.

STEP 16. Cut off excess cable, leaving approximately 1/2" inside the sheave.

STEP 17. Proceed to paragraph 4.10 for potentiometer phasing procedure.

4.9.3 Rear Pen on Dual Channel Recorders

Refer to Figure 4-6 which shows cable correctly strung. On recorders having a side-by-side pen system, remove the stop temporarily from the rear pen rod.

STEP 1. Rotate the potentiometer sheave fully CCW. Be sure the hole in the sheave faces the front of the recorder (away from the technician). If it does not, loosen the set screw in the sheave, adjust the sheave position, and retighten the set screw.

STEP 2. Using a 60-inch length of cable, insert about 2 inches through the hole in the sheave. Wrap the cable 1 turn CW around the left-hand 4-40 screw inside the sheave and tighten the screw.

STEP 3. Wrap the cable 1/2 turn CCW around the spring-loaded idler pulley at the left of the potentiometer. Pull the cable taut enough so the pulley arm moves through a 120° arc.

STEP 4. Wrap 1/2 turn CW around the right-hand stationary idler pulley at the rear of the recorder.

STEP 5. Wrap 1 turn CW around the right-hand servo motor sheave.

STEP 6. Wrap 1/2 turn CW around the upper rear pulley on the bracket at the left-hand side of the recorder.

STEP 7. Slide the pen bearing to its extreme right-hand limit of travel.

4.9.3 Continued

STEP 8. Insert the cable through the slot in the pen bearing.

STEP 9. Loop the cable under the corner of the pen bearing and back through the slot. Repeat the loop to obtain two loops.

STEP 10. Wrap the cable 1/2 turn CW around the upper rear pulley on the bracket at the right-hand side of the recorder.

STEP 11. Holding the cable taut, rotate the potentiometer CW, wrapping the cable from the spring-loaded idler pulley around the sheave until the pen bearing reaches its full left-hand limit of travel. The cable must be aligned progressively UP the sheave.

STEP 12. Place the free end of the cable on the potentiometer sheave beneath the cable from the spring-loaded idler pulley and wrap the cable CCW around the potentiometer sheave to the hole. Insert the cable end through the hole. Wrap the cable 1 turn CW around the remaining 4-40 screw inside the sheave and tighten the screw.

STEP 13. Move the pen bearing back and forth to assure that the stringing system is operating smoothly. When the pen bearing moves from right to left, the cable from the spring-loaded idler pulley should wrap progressively UP the potentiometer sheave. When the pen bearing moves from left to right, the cable leaving the right-hand pulley should wrap progressively DOWN the potentiometer sheave.

STEP 14. Cut off excess cable, leaving approximately 1/2" inside the sheave.

STEP 15. Proceed to paragraph 4.10 for potentiometer phasing procedure.

4.10 POTENTIOMETER PHASING

STEP 1. Move the pen bearing to its extreme-right-hand limit of travel.

4.10 Continued

> NOTE
>
> "Right-Hand" as meant with the rear of the recorder toward the operator, and the recorder upright.

STEP 2. Connect the leads of an ohmmeter (reading on lowest resistance scale) between the CCW and S terminals of the potentiometer. If the ohmmeter reading is 125 ± 10 ohms, the potentiometer is properly phased. If not, proceed to Step 3.

STEP 3. Loosen the set screw in the potentiometer sheave using a 6-32 Allen wrench.

STEP 4. Holding the pen bearing in position (extreme right-hand limit), rotate the potentiometer shaft until the ohmmeter reads 125 ± 10 ohms.

STEP 5. Tighten the set screw in the potentiometer sheave.

STEP 6. On recorders having a side-by-side pen system, replace the pen stop(s) on the pen rod(s).

STEP 7. If, after the recorder has been placed in operation, the ZERO control does not permit full scale zero adjustment, the potentiometer must be rephased, as above described. If less than full scale zero adjustment is obtained, the potentiometer resistance should be set at greater than 125 ohms.

4.11 CHART DRIVE MOTOR REPLACEMENT

STEP 1. Partially disassemble the recorder by removing the pen(s), the ink cartridge(s), and the chart paper.

STEP 2. Remove the case top by tilting the top upward, grasping the top by the rear edge of the right-hand side piece, and springing the side piece away from the recorder to disengage the right-hand hinge pin. See Figure 2-1. Move the top to the left to disengage it from the right-hand hinge pin.

4.11 Continued

STEP 3. Hold the platen and turn the recorder upside down.

STEP 4. Disconnect the leads of the motor to be replaced from terminal board TB308. See Figure 2-2.

STEP 5. Remove the two 4-40 screws holding the mounting plate to the left-hand side frame and remove the motor/mounting plate subassembly.

STEP 6. Attach the replacement motor to the mounting plate using the two screws provided. If the motor is equipped with a terminal strip, mount the terminal strip under the right-hand motor mounting screw.

STEP 7. Align the motor/mounting plate subassembly with the holes in the left-hand side frame, and fasten the subassembly in place using the 4 -40 screws and lockwashers removed in step 5. Do not tighten the screws.

STEP 8. Adjust the subassembly position so that the motor gear engages the idler. Be sure that minimal backlash exists between the motor gear and idler, i.e., slight mechanical oscillation should exist between the gears. Loosen the set screw and center the motor gear with the idler.

STEP 9. Tighten the screws.

STEP 10. Place the motor electrical leads through the front slot in the bottom of the left-hand side frame. Connect the replacement motor leads to terminals 1 and 3 or 3 and 5 of TB308. See Figure 2-2. When the replacement motor is equipped with a terminal strip, remove the capacitor on TB308 between the terminals for the replacement motor.

STEP 11. Reassemble the recorder, reversing the procedure of steps 1 through 4.

4.12 POTENTIOMETER REPLACEMENT

Disassemble the recorder following Steps 1 through 8 of paragraph 4.7.2. The technician will now be facing the rear of the recorder. On recorders

having a side-by-side pen system, romove the stop temporarily form the appropriate pen rod.

STEP 1. Move the pen bearing to its extreme right-hand limit of travel.

> NOTE
>
> "Right-hand" as meant with the rear of the recorder toward the operator, and the recorder upright.

STEP 2. Loosen the set screw in the potentiometer sheve using a 6-32 Allen wrench.

STEP 3. Push the sheave down onto the servo mounting plate and tape the sheave in place with masking tape. The stringing should not be disturbed.

STEP 4. Turn the recorder upside down. See Figure 4-4.

STEP 5. Unsolder the leads and capacitor from the potentiometer, noting the relative locations of the leads on the potentiometer terminals.

STEP 6. Remove the three 4-40 screws and potentiometer clamps and remove the potentiometer.

STEP 7. Rotate the shaft of the new potentiometer fully CCW.

STEP 8. Position the potentiometer so the terminals face the front of the recorder and insert the potentiometer shaft into the sheave. Replace the three 4-40 screws and potentiometer clamps.

STEP 9. Solder the leads and capacitor to the potentiometer terminals.

STEP 10. Turn the recorder over.

STEP 11. Remove the masking tape from the potentiometer sheave. Raise the sheave until the cable from the sheave to the right-hand pulley is horizontal. Retighten the set screw in the potentiometer sheave.

STEP 12. Phase the potentiometer, following the instructions given in paragraph 4.10.

## 4.13 CONVERSION BETWEEN SIDE-BY-SIDE (5-INCH SPAN) AND CROSS-OVER (10-INCH SPAN) PEN SYSTEMS

The pen travel stops, with side-by-side pen operation, are located on the pen rods. To convert to cross-over (10-inch span) pen systems, perform the following steps:

STEP 1. Remove the pen stops from the pen rods.

STEP 2. Change the scale to indicate a 10-inch span.

STEP 3. Change to an appropriate chart paper.

STEP 4. On single-span recorders, change the span element - see Table I.

STEP 5. Reset the CAL adjustment following the procedure given in paragraph 4.8.2.

STEP 6. Reverse the polarity of the input signal to the front pen.

To convert from cross-over (10-inch span) to a side-by-side pen system, the pen stops are positioned to permit 5-inch pen travel and the scale is changed accordingly. Follow Steps 3, 4, 5, and 6 above. In addition, for multiple-span recorders the SPAN switch must be set at twice the desired span. For example, if 20 mv full scale was being monitored over the 10-inch span, and it is desired to monitor this over the 5-inch span the SPAN switch must be set at 400 mv.

# SECTION 5
# PARTS LISTS

This section contains the following parts lists:


| | | Page |
|---|---|---|
| TABLE 5-1 | STANDARD CHART DRIVE ASSEMBLIES | 5-2 |
| TABLE 5-2 | OPTIONAL CHART DRIVE MOTOR ASSEMBLIES | 5-2 |
| TABLE 5-3 | ELECTRICAL PARTS LISTS - BASIC RECORDERS | 5-3 |
| TABLE 5-4 | ELECTRICAL PARTS LISTS - ACCESSORIES AND OPTIONS | 5-13 |
| TABLE 5-5 | REPLACEMENT PARTS AND KITS | 5-14 |
| TABLE 5-6 | STRIP CHART RECORDER PAPER | 5-15 |
| TABLE 5-7 | INDICATING SCALES | 5-16 |
| TABLE 5-8 | INKS AND ACCESSORIES | 5-16 |

TABLE 5-1. STANDARD CHART DRIVE MOTOR ASSEMBLIES

| Gear Set | Chart Speeds for Ratio Switch Positions | | | | Chart Motor Assembly Number | | Motor Speed RPM |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 4 | 8 | 60 Hz. | 50 Hz. | |
| | inches per hour | | | | | | |
| S | 1 | 2 | 4 | 8 | 972-891-01 | 972-891-41 | 1/20 |
| | inches per minute | | | | | | |
| M | 1 | 2 | 4 | 8 | 972-891-02 | 972-891-42 | 3 |

TABLE 5-2 OPTIONAL CHART DRIVE MOTOR ASSEMBLIES

| Gear Set | Chart Speeds for Ratio Switch Posiitons | | | | Chart Motor Assembly Number | | Motor Speed RPM |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 4 | 8 | 50 Hz. | 60 Hz. | |
| | inches per hour | | | | | | |
| A | 1/12 | 1/6 | 1/3 | 2/3 | 972-891-43 | 972-891-03 | 1/240 |
| B | 1/6 | 1/3 | 2/3 | 1 1/3 | 972-891-44 | 972-891-04 | 1/120 |
| Q | 1/3 | 2/3 | 1 1/2 | 2 2/3 | 972-891-45 | 972-891-05 | 1/60 |
| C | 1/2 | 1 | 2 | 4 | 972-891-46 | 972-891-06 | 1/40 |
| R | 2/3 | 1 1/2 | 2 2/3 | 5 1/3 | 972-891-47 | 972-891-07 | 1/30 |
| D | 2 | 4 | 8 | 16 | 972-891-48 | 972-891-08 | 1/10 |
| E | 2 1/2 | 5 | 10 | 20 | 972-891-49 | 972-891-09 | 1/8 |
| F | 4 | 8 | 16 | 32 | 972-891-50 | 972-891-10 | 1/5 |
| G | 5 | 10 | 20 | 40 | 972-891-51 | 972-891-11 | 1/4 |
| P | 7 1/2 | 15 | 30 | 60 | 972-891-58 | 972-891-18 | 3/8 |
| H | 10 | 20 | 40 | 80 | 972-891-53 | 972-891-13 | 1/2 |
| | inches per minute | | | | | | |
| J | 1/4 | 1/2 | 1 | 2 | 972-891-54 | 972-891-14 | 3/4 |
| K | 1/3 | 2/3 | 1 1/3 | 2 2/3 | 972-891-55 | 972-891-15 | 1 |
| L | 2/3 | 1 1/3 | 2 2/3 | 5 1/3 | 972-891-56 | 972-891-16 | 2 |
| N | 2 | 4 | 8 | 16 | 972-891-57 | 972-891-17 | 6 |

TABLE 5-3 ELECTRICAL PARTS LISTS - BASIC RECORDERS

| Schematic Reference | Description | Varian Part Number |
|---|---|---|
| **Recorder Subassembly - Part No. E972-370** | | |
| DS301 | Lamp, neon, amber lens | 67-499-961 |
| F301 | Fuse | See par. 2.2 |
| J406 | Connector, receptacle (accessories only) | 51-107-701 |
| P406 | Connector, plug (accessories only) | 51-107-700 |
| S301 | Power switch, toggle, DPST | 71-139-990 |
| S302 | Chart drive switch, toggle, DPDT | 71-149-960 |
| **Servo Mounting Plate Assembly - Part No. D972-340** | | |
| B304 | Motor, servo | 943-364 |
| B305 | Motor, servo | 943-364 |
| C304 | Capacitor, 0.5 mfd, 200 V | 907-529-05 |
| C305 | Capacitor, 0.5 mfd, 200 V | 907-529-05 |
| R301 | Potentiometer, feedback | 906-549 |
| R302 | Potentiometer, feedback | 906-549 |
| **Parallel T Filter Assembly - Part No. C972-541** | | |
| C701 | Capacitor, 0.25 mfd, 200 V | 907-527-02 |
| C702 | Capacitor, 0.25 mfd, 200 V | 907-527-02 |
| C703 | Capacitor, 0.5 mfd, 200 V | 907-527-01 |
| R701 | Resistor, 11.3K, 1% (60 Hz only) | 31-605-113 |
| R701 | Resistor, 13.7K, 1% (50 Hz only) | 31-605-137 |
| R702 | Resistor, 11.3K, 1% (60 Hz only) | 31-605-113 |
| R702 | Resistor, 13.7K, 1% (50 Hz only) | 31-605-137 |
| R703 | Resistor, 5.62K, 1% (60 Hz only) | 31-604-562 |
| R703 | Resistor, 6.81K, 1% (50 Hz only) | 31-604-681 |
| **Amplifier Subassembly, Right Hand - Part No. D972-365**<br>**Amplifier Subassembly, Left Hand - Part No. D972-553** | | |
| C401 | Capacitor, 0.022 mfd, 200 V | 41-724-955 |
| CH101 | Contact Modulator | 905-523 |
| J401 | Input terminal, red | 51-799-942 |
| J402 | Input terminal, black | 51-799-941 |
| J403 | Input terminal, silver (uninsulated) | 51-799-984 |

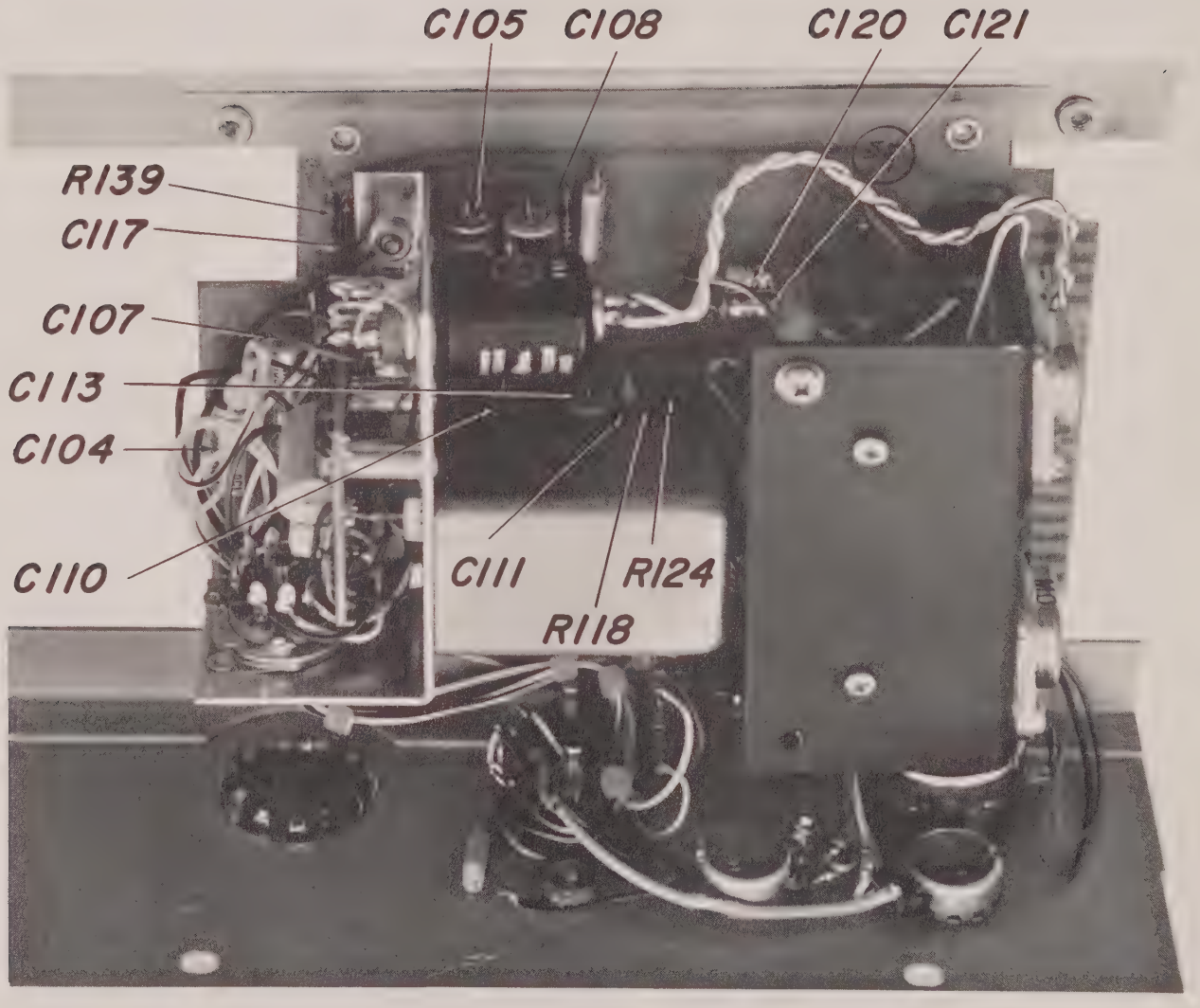



**Figure 5-1. Single Channel Amplifier**

TABLE 5-3 Continued

| Schematic Reference | Description | Varian Part Number |
|---|---|---|
| R401 | Resistor, 15K, 1/4w, 5% | 32-301-515 |
| R402 | Potentiometer, 25K, Gain | 972-523-02 |
| R403 | Potentiometer, 1.5K, Cal | 37-586-415 |
| R404 | Potentiometer, 5K, Zero | 971-570 |
| R405 | Potentiometer, 100K, Damp | 972-523-03 |
| | **Input Assembly - Part No. D972-478** | |
| T101 | Transformer, input | 907-753 |
| | **Output Assembly - Part No. D972-477** | |
| C118 | Capacitor, 0.5 mfd, 200 V | 907-529-05 |
| C119 | Capacitor, 0.5 mfd, 200 V | 907-529-05 |
| Q109 | Transistor, DTG-110 | 62-989-750 |
| Q110 | Transistor, DTG-110 | 62-989-750 |
| T102 | Transformer, output | 972-070 |
| | **Amplifier P.C. Board Assembly, R.H. Channel - Part No. D972-096** | |
| | **Amplifier P.C. Board Assembly, L.H. Channel - Part No. D972-480** | |
| C104 | Capacitor, 150 mfd, 3 V | 41-506-227 |
| C105 | Capacitor, 35 mfd, 25 V | 41-506-000 |
| C106 | Capacitor, 0.022 mfd, 200 V | 41-724-955 |
| C107 | Capacitor, 100 mfd, 12 V | 41-506-253 |
| C108 | Capacitor, 35 mfd, 25 V | 41-506-000 |
| C109 | Capacitor, 10 mfd, 15 V | 41-506-239 |
| C110 | Capacitor, 100 mfd, 3 V | 41-506-002 |
| C111 | Capacitor, 0.033 mfd, 200 V | 41-724-973 |
| C112 | Capacitor, 25 mfd, 12 V | 41-506-219 |
| C113 | Capacitor, 100 mfd, 12 V | 41-506-253 |
| C114 | Capacitor, 10 mfd, 25 V | 41-506-244 |
| C115 | Capacitor, 10 mfd, 25 V | 41-506-244 |
| C116 | Capacitor, 10 mfd, 25 V | 41-506-244 |
| C117 | Capacitor, 0.056 mfd, 200 V(-30 version only) | 907-527-08 |
| C117 | Capacitor, 0.047 mfd, 200 V(-01,-02,and -04 versions) | 41-724-962 |
| C120 | Capacitor, 5 mfd, 12 V | 41-506-236 |
| C121 | Capacitor, 5 mfd, 12 V | 41-506-236 |
| CR101 | Diode, 1N475A | 66-300-457 |
| CR102 | Diode, 1N457A | 66-300-457 |
| CR103 | Diode, 1N457A | 66-300-457 |
| CR104 | Diode, 1N457A | 66-300-457 |

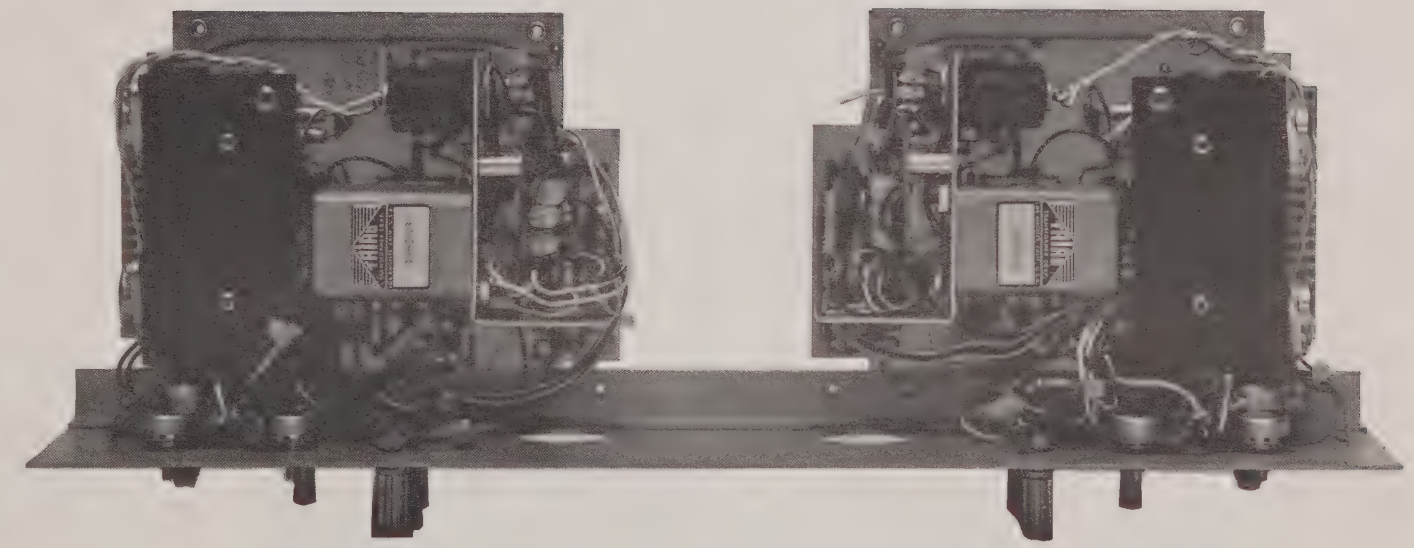


Figure 5-2

TABLE 5-3 Continued

| Schematic Reference | Description | Varian Part Number |
|---|---|---|
| Q101 | Transistor, 2N4250 | 62-904-250 |
| Q102 | Transistor, 2N3391A | 62-003-391 |
| Q103 | Transistor, 2N3391A | 62-003-391 |
| Q104 | Transistor, 2N3906 | 62-903-906 |
| Q105 | Transistor, 2N3391A | 62-003-391 |
| Q106 | Transistor, 2N3391A | 62-003-391 |
| Q107 | Transistor, 2N3904 | 62-903-904 |
| Q108 | Transistor, 2N3904 | 62-903-904 |
| R104 | Resistor, 18K, 1/4w, 5% | 32-301-518 |
| R105 | Resistor, 180K, 1/4w, 5% | 32-301-618 |
| R106 | Resistor, 100 ohms, 1/4w, 5% | 32-301-310 |
| R107 | Resistor, 22K, 1/4w, 5% | 32-301-522 |
| R108 | Resistor, 10K, 1/4w, 5% | 32-301-510 |
| R109 | Resistor, 150 ohms, 1/4w, 5% | 32-301-315 |
| R110 | Resistor, 18K, 1/4w, 5% | 32-301-518 |
| R111 | Resistor, 2.2K, 1/4w, 5% | 32-301-422 |
| R112 | Resistor, 18K, 1/4w, 5% | 32-301-518 |
| R113 | Resistor, 270 ohms, 1/4w, 5% | 32-301-327 |
| R114 | Resistor, 27K, 1/4w, 5% | 32-301-527 |
| R115 | Resistor, 15K, 1/4w, 5% | 32-301-515 |
| R116 | Resistor, 270 ohms, 1/4w, 5% | 32-301-327 |
| R117 | Resistor, 22K, 1/4w, 5% | 32-301-522 |
| R118 | Resistor, 10K, 1/4w, 5% | 32-301-510 |
| R119 | Resistor, 10K, 1/4w, 5% | 32-301-510 |
| R120 | Resistor, 2.7K, 1/4w, 5% | 32-301-427 |
| R121 | Resistor, 120 ohms, 1/4w, 5% | 32-301-312 |
| R122 | Resistor, 1.8K, 1/4w, 5% | 32-301-418 |
| R123 | Resistor, 120 ohms, 1/4w, 5% | 32-301-312 |
| R124 | Resistor, 2.7K, 1/4w, 5% | 32-301-427 |
| R125 | Resistor, 4.7K, 1/4w, 5% | 32-301-447 |
| R126 | Resistor, 1.5K, 1/2w, 5% | 32-201-415 |
| R127 | Resistor, 4.7K, 1/4w, 5% | 32-301-447 |
| R130 | Resistor, 120 ohms, 1/4w, 5% | 32-301-312 |
| R131 | Resistor, 120 ohms, 1/4w, 5% | 32-301-312 |
| R132 | Resistor, 8.2K, 1/4w, 5% | 32-301-482 |
| R133 | Resistor, 220 ohms, 1/4w, 5% | 32-301-322 |
| R134 | Resistor, 220 ohms, 1/4w, 5% | 32-301-322 |
| R135 | Resistor, 8.2K, 1/4w, 5% | 32-301-482 |
| R136 | Resistor, 680 ohms, 1w, 5% | 33-301-368 |
| R137 | Resistor, 2 ohms 1/2w, 5% | 32-201-120 |
| R138 | Resistor, 9.09K, M.F., 1% (-01 and -04 versions) | 31-604-909 |
| R139 | Resistor, 972 K, M.F., 1% (-01, -02, and -04 versions) | 31-606-972 |
| R139 | Resistor, 715K, 1% (-03 version only) | 31-606-715 |
| R140 | Resistor, 2 ohms, 1/2w, 5% | 32-201-120 |
| R141 | Resistor, 2 ohms, 1/2w, 5% | 32-201-120 |

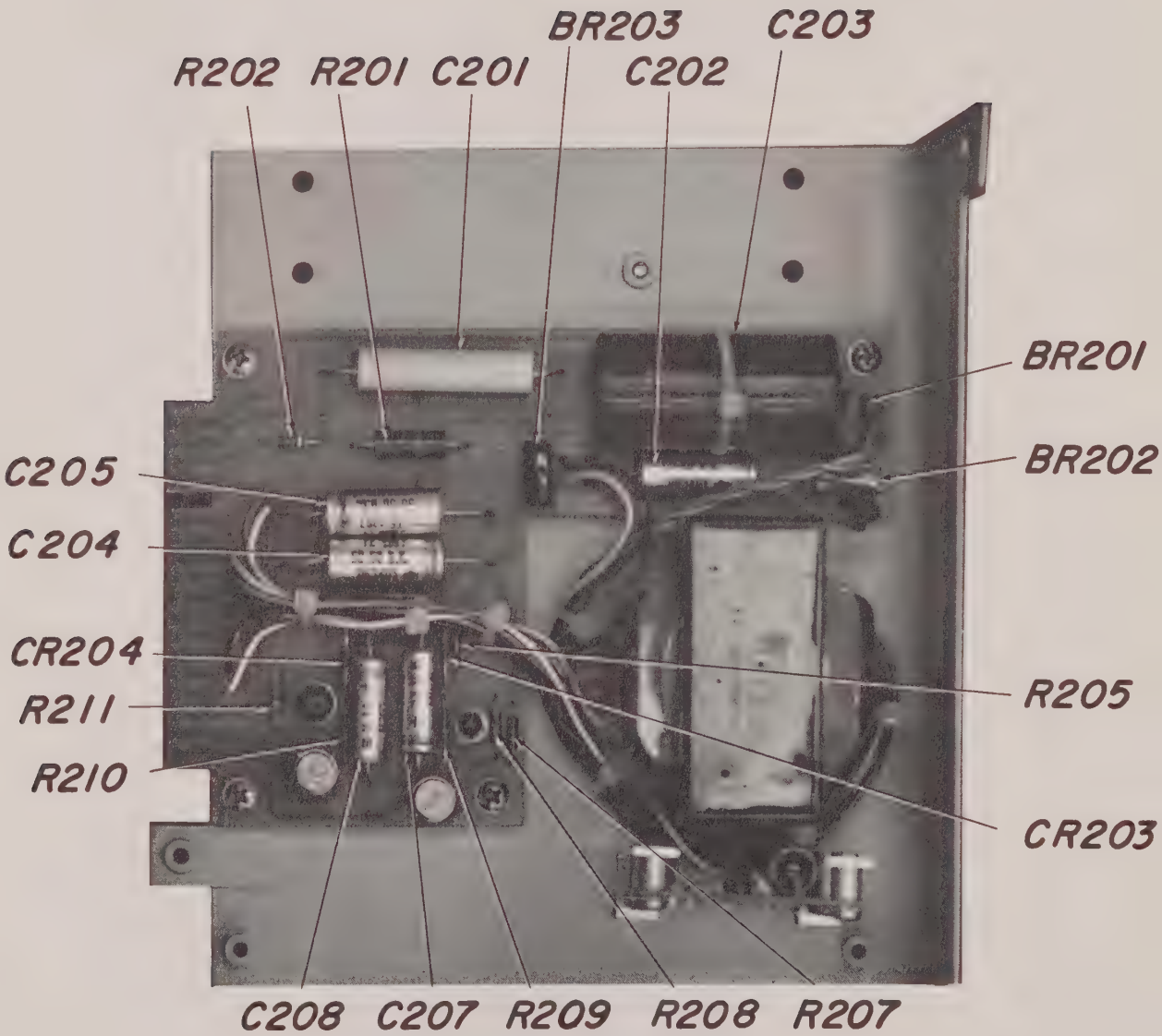



Figure 5-3. 115V Power Supply

TABLE 5-3 Continued

| Schematic Reference | Description | Varian Part Number |
|---|---|---|
| R142 | Resistor, 3.9K, 1/4w, 5% | 32-301-439 |
| R143 | Resistor, 33K, 1/4w, 5% | 32-301-533 |
| R144 | Resistor, 100K, 1% | 31-606-100 |
| R145 | Resistor, 3.01K, 1% | 31-224-301 |
| **Power Supply Assembly - Part No. D972-088** | | |
| L201 | Choke, Tranex No. 1-0227 (230 V only) | 972-092 |
| R213 | Resistor, 350 ohms, 5w, 5% (230 V only) | 35-289-335 |
| T201 | Transformer, power | 972-077 |
| **Reference Supply Assembly - Part No. A971-724** | | |
| C206 | Capacitor, 200 mfd, 10 V | 41-506-225 |
| CR201 | Diode, Zener, LMZX22A | 66-393-402 |
| CR202 | Diode, Zener, 1N936 | 66-300-936 |
| R203 | Resistor, 820 ohms, 1w, 5% | 33-301-382 |
| R204 | Resistor, 1.5K, 1/4w, 5% | 32-301-415 |
| **Power Supply P.C. Board Assembly - Part No. D972-089** | | |
| C201 | Capacitor, 2 mfd, 200 V, | 41-729-580 |
| C202 | Capacitor, 100 mfd, 50 V | 41-506-229 |
| C203 | Capacitor, 500 mfd, 50 V | 41-508-881 |
| C204 | Capacitor, 100 mfd, 50 V | 41-506-229 |
| C205 | Capacitor, 100 mfd, 50 V | 41-506-229 |
| C207 | Capacitor, 50 mfd, 25 V | 41-506-256 |
| C208 | Capacitor, 50 mfd, 25 V | 41-506-256 |
| C209 | Capacitor, 0.5 mfd, 200 V (60 Hz only) | 41-729-541 |
| C209 | Capacitor, 1 mfd, 200 V (50 Hz only) | 41-729-513 |
| CR203 | Diode, Zener, LMZX22A | 66-393-402 |
| CR204 | Diode, Zener, LMZX22A | 66-393-402 |
| BR201 | Diode bridge, BR84C | 908-047-01 |
| BR202 | Diode bridge, BR84C | 908-047-01 |
| BR203 | Diode bridge, BR84C | 908-047-01 |

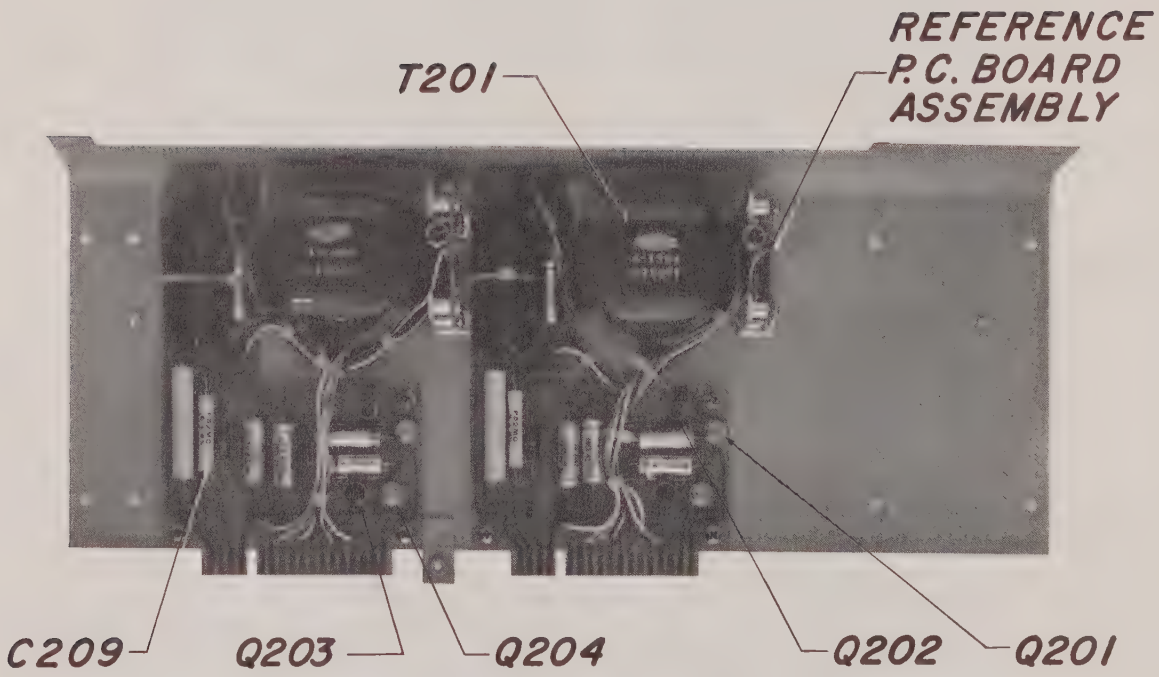



Figure 5-4 Dual 115V Power Supply

TABLE 5-3 Continued

| Schematic Reference | Description | Varian Part Number |
|---|---|---|
| Q201 | Transistor, 40319 | 62-989-600 |
| Q202 | Transistor, 2N3391A | 62-003-391 |
| Q203 | Transistor, 2N3638 | 62-903-638 |
| Q204 | Transistor, 2N3053 | 62-003-053 |
| R201 | Resistor, 1.5K, 1w, 5% | 33-301-415 |
| R202 | Resistor, 560 ohms, 1/4w, 5% | 32-301-356 |
| R205 | Resistor, 1.8K, 1/4w, 5% | 32-301-418 |
| R206 | Resistor, 1.8K, 1/4w, 5% | 32-301-418 |
| R207 | Resistor, 150 ohms, 1/4w, 5% | 32-301-315 |
| R208 | Resistor, 1.2K, 1/4w, 5% | 32-301-412 |
| R209 | Resistor, 2.2K, 1/4w, 5% | 32-301-422 |
| R210 | Resistor, 2.2K, 1/4w, 5% | 32-301-422 |
| R211 | Resistor, 1.2K, 1/4w, 5% | 32-301-412 |
| R212 | Resistor, 150 ohms, 1/4w, 5% | 32-301-315 |
| Switch Assembly - Part No. D972-530 | | |
| R501 | Resistor, 990K, 0.1% | 31-613-280 |
| R502 | Resistor, 6K, 0.1% | 31-613-281 |
| R503 | Resistor, 2K, 0.1% | 31-613-282 |
| R504 | Resistor, 2K, 0.1% | 31-613-282 |
| R505 | Potentiometer, 50K | 971-568 |
| R506 | Resistor, 2.7K, 1/4w, 5% | 32-301-427 |
| R507 | Resistor, 14K, 0.1% | 31-613-274 |
| R508 | Resistor, 8.4K, 0.1% | 31-613-275 |
| R509 | Resistor, 2.8K, 0.1% | 31-613-276 |
| R510 | Resistor, 1.4K, 0.1% | 31-613-277 |
| R511 | Resistor, 840 ohms, 0.1% | 31-613-278 |
| R512 | Resistor, 280 ohms, 0.1% | 31-613-279 |
| R513 | Resistor, 280 ohms, 0.1% | 31-613-279 |
| R514 | Resistor, 20K, 1% | 31-605-200 |
| R515 | Resistor, 10K, 1% | 31-605-100 |
| R516 | Resistor, 11.3K, 1% | 31-605-113 |
| R517 | Resistor, 4.42K, 1% | 31-604-442 |
| R518 | Resistor, 2.32K, 1% | 31-604-232 |
| R519 | Resistor, 1.3K, 1% | 31-604-130 |
| R520 | Resistor, 499 ohms, 1% | 31-603-499 |
| R521 | Resistor, 499 ohms, 1% | 31-603-499 |

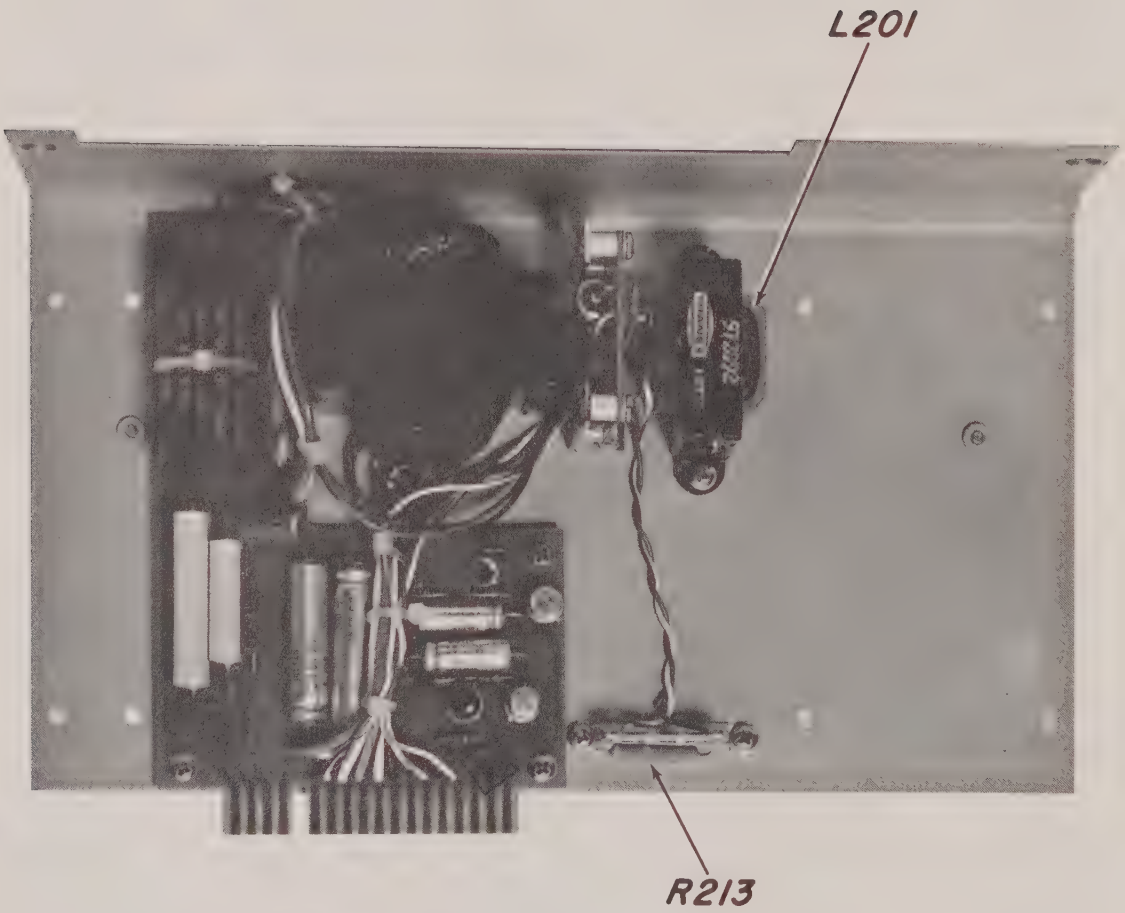



Figure 5-5. 230V Power Supply

TABLE 5-4 ELECTRICAL PARTS LISTS - ACCESSORIES AND OPTIONS

| Schematic Reference | Description | Varian Part Number |
|---|---|---|
| **Accessory Power Supply Kit - Part No. A972-581** | | |
| C305 | Capacitor, 50 mfd, 50 V | 41-506-259 |
| CR304 | Diode, SC2 | 66-396-832 |
| CR305 | Diode, SC2 | 66-396-832 |
| CR306 | Diode, SC2 | 66-396-832 |
| T301 | Transformer, power | 907-200 |
| **Electric Pen Lift Kit - Part No. B972-578** | | |
| CR303 | Diode, SC2 | 66-396-832 |
| L303 | Solenoid | 972-827 |
| R303 | Resistor, 51 ohms, 2w, 5% (60 HZ only) | 34-401-251 |
| R303 | Resistor, 24 ohms, 2w, 5% (50 HZ only) | 34-401-224 |
| **Event Marker Kit - Part No. 972-640** | | |
| C306 | Capacitor, 0.022 mfd, 200 V (left-hand) | 41-724-955 |
| C307 | Capacitor, 0.022 mfd, 200 V (left-hand) | 41-724-955 |
| C308 | Capacitor, 0.022 mfd, 200 V (right-hand) | 41-724-955 |
| C309 | Capacitor, 0.022 mfd, 200 V (right-hand) | 41-724-955 |
| **Retransmitter Kit - Part No. 972-809** | | |
| R304 and/or R305 | Retransmitting potentiometer (specify resistance) (includes feedback potentiometer) | 907-538-xx |

TABLE 5-5

## REPLACEMENT PARTS AND KITS

| Description | Varian Part Number |
|---|---|
| Instruction manual | 87-300-112 |
| Pen filler | 907-674 |
| Pen cleaning wire | 972-499 |
| Motor oil | 88-299-450 |
| Chart-weight clip | 972-529 |
| Fuse | See para. 2.2 |
| Drive cable | 88-589-990 |
| Span element | See Table II |
| Potentiometer, feedback | 906-549 |
| Neon lamp | 67-499-961 |
| Alarm/Control switch kit (front) | 972-466-01 |
| Alarm/Control switch kit (rear) | 972-466-02 |
| Event Marker kit, right side | 972-640-01 |
| Event Marker kit, left side | 972-640-02 |
| Z-Fold Paper Tray | 972-781-02 |
| Retransmitter Kit (specify resistance) | 972-809 |
| Integrator Kit | 972-851 |

TABLE 5-6 STRIP CHART RECORDER PAPER

In addition to the charts listed below, many other types can be supplied on special request. Printing plates are on hand for these special types, and new plates can be prepared for many more special requirements. A minimum order of 50 rolls is normally required for special charts, and price details are available from the factory.

GENERAL DESCRIPTION: Unless otherwise noted, 10-inch charts are in roll form and have the following characteristics:

Length: 120 feet
Overall width: 11 5/16 inches
Marking: number of feet remaining is printed in margin every one foot

Color: white paper, printed in gray

| Calibration | Line Spacing Across Chart | Line Spacing Along Time Axis | Chart Type | Part Number | Remarks |
|---|---|---|---|---|---|
| 0 to 10 | 100 divisions across 10" | 1/10" | 154A | 971-490-03 | Special order only |
| 0 to 10 | 100 divisions across 10" | 1/4" | 155A | 971-490-02 | Special order only |
| 0 to 10 | 100 divisions across 10" | 1/4" | 410 | 972-004-01 | Folded chart, for ink recording. 200 perforated sections, each 8" long. Total length is 133 feet. |
| 0 to 10 | 100 divisions across 10" | 1/4" | 410L | 972-004-02 | Same as Type 410 except 800 sheets. Total length approximately 534 feet. |
| 0 to 10 | 100 divisions across 10" | 1/3" | 158A | 971-490-01 | |
| 10 to 0 | 100 divisions across 10" | 1/3" | 159A | 972-053 | |
| 5 to 0 to 5 | 100 divisions across 10" | 1/3" | 160A | 972-196 | |
| 10-0 0-10 | Dual grid, each across 4.83", plus 3 divisions below "0" | 1/3" | 114A | 972-262 | |
| 10-0 0-10 | Dual grid, each across 4.442", plus 3 divisions below "0"; 10 divisions across 0.75" for integrator | 1/3" | 116A | 972-267 | For use with integrator attachment. |
| | | | | | For use with integrator attachment. |
| 10 to 0 | 100 divisions across 8.93" plus 3 divisions below "0"; 10 divisions across 0.75" for integrator | 1/3" | 146A | 972-268 | For use with integrator attachment. |
| 10 to 0 | 100 divisions across 9.71" plus 3 divisions below "0" | 1/3" | 161A | 972-260 | |
| 5-0 0-5 | Dual grid, each across 4.83"; 0.34" between charts | 1/3" | 162A | 972-504 | |

TABLE 5-7 INDICATING SCALES

| For Use with Charts | Calibration | Scale Type | Part Number |
|---|---|---|---|
| 114A | 10-0 and 0-10, 100 divisions | 114A-2 | 972-282 |
| 116A | 10-0 and 0-10 integrator, 100 divisions | 116A-2 | 972-283 |
| 118A | 10-0 and 0-10, 100 divisions dual integrators | — | — |
| 146A | 10-0 Integrator, 100 divisions | 146A-2 | 972-284 |
| 158A | 0-10, 100 divisions | 158A-2 | 972-494 |
| 159A | 10-0, 100 divisions | 159A-2 | 972-495 |
| 160A | 5-0-5, 100 divisions | 160A-2 | 972-496 |
| 161A | 10-0, 100 divisions | 161A-2 | 972-280 |
| 162A | 5-0 and 0-5, 100 divisions | 162A-2 | 972-505 |

TABLE 5-8 INKS AND ACCESSORIES

Standard Recorder Ink

For general purpose recording. Water soluble ink, non-clogging, medium drying. Suitable for both continuous and intermittent recording usage. Each cartridge holds 0.85 cc. Cartons of 12 available at reduced rate.

| Item | Part Number |
|---|---|
| Ink cartridge, red | 908-049-01 |
| Ink cartridge, blue | 908-049-02 |
| Ink cartridge, black | 908-049-03 |
| Ink cartridge, green | 908-049-04 |
| Ink cartridge, purple | 908-049-05 |

Table 5-8 Continued Special Purpose Inks

Slow Drying Ink: Recommended for use with chart speeds of 12 inches/hour or slower, especially where "noisy" signals are involved. Water soluble ink, nonclogging, very slow drying. Each cartridge holds 0.85 cc. Cartons of 12 at reduced rate.

| Item | Part Number |
|---|---|
| Ink cartridge, red | 908-049-11 |
| Ink cartridge, blue | 908-049-12 |
| Ink cartridge, black | 908-049-13 |
| Ink cartridge, green | 908-049-14 |
| Ink cartridge, purple | 908-049-15 |

Fast Drying Ink: Water soluble ink, very fast drying. Cleaning of pen system recommended after using recorder, to prevent clogging. Each cartridge holds 0.85 cc. Cartons of 12 available at reduced rate.

| Item | Part Number |
|---|---|
| Ink cartridge, red | 908-049-06 |
| Ink cartridge, blue | 908-049-07 |
| Ink cartridge, black | 908-049-08 |
| Ink cartridge, green | 908-049-09 |
| Ink cartridge, purple | 908-049-10 |

## INKING SYSTEM ACCESSORIES

| Description | Varian Part Number |
|---|---|
| Pen cleaning kit, including 1-foot pen cleaning wire and one pen filler | 971-395 |
| Pen kits (all kits contain: front pen assembly, pen filler, pen cleaning wire, 2 cartridges of red ink) | |
| Single Channel Pen Kit | 972-803-01 |
| Dual Channel Pen Kit, including side-by-side or cross-over rear pen assembly and 2 cartridges of blue ink | 962-803-02 |
| Dual Channel Pen Kit, including overlapping rear pen assembly and 2 cartridges of blue ink | 972-803-03 |
| Dual Channel Pen Kit, including side-by-side rear pen assembly and 2 cartridges of blue ink | 972-803-04 |

## RECORDER PENS

| Description | Varian Part Number |
|---|---|
| Single channel pen assembly | 972-735-01 |
| Dual channel pen assemblies | |
| Front pen | 972-735-01 |
| Rear pen, side-by-side or cross over | 972-735-02 |
| Rear pen, overlapping | 972-735-03 |
| Rear pen, side-by-side | 972-735-04 |
| Event marker pen, left hand | 972-641-02 |
| Event marker pen, right hand | 972-641-01 |

TABLE 5-9 MISCELLANEOUS SUPPLIES
Economy Packages

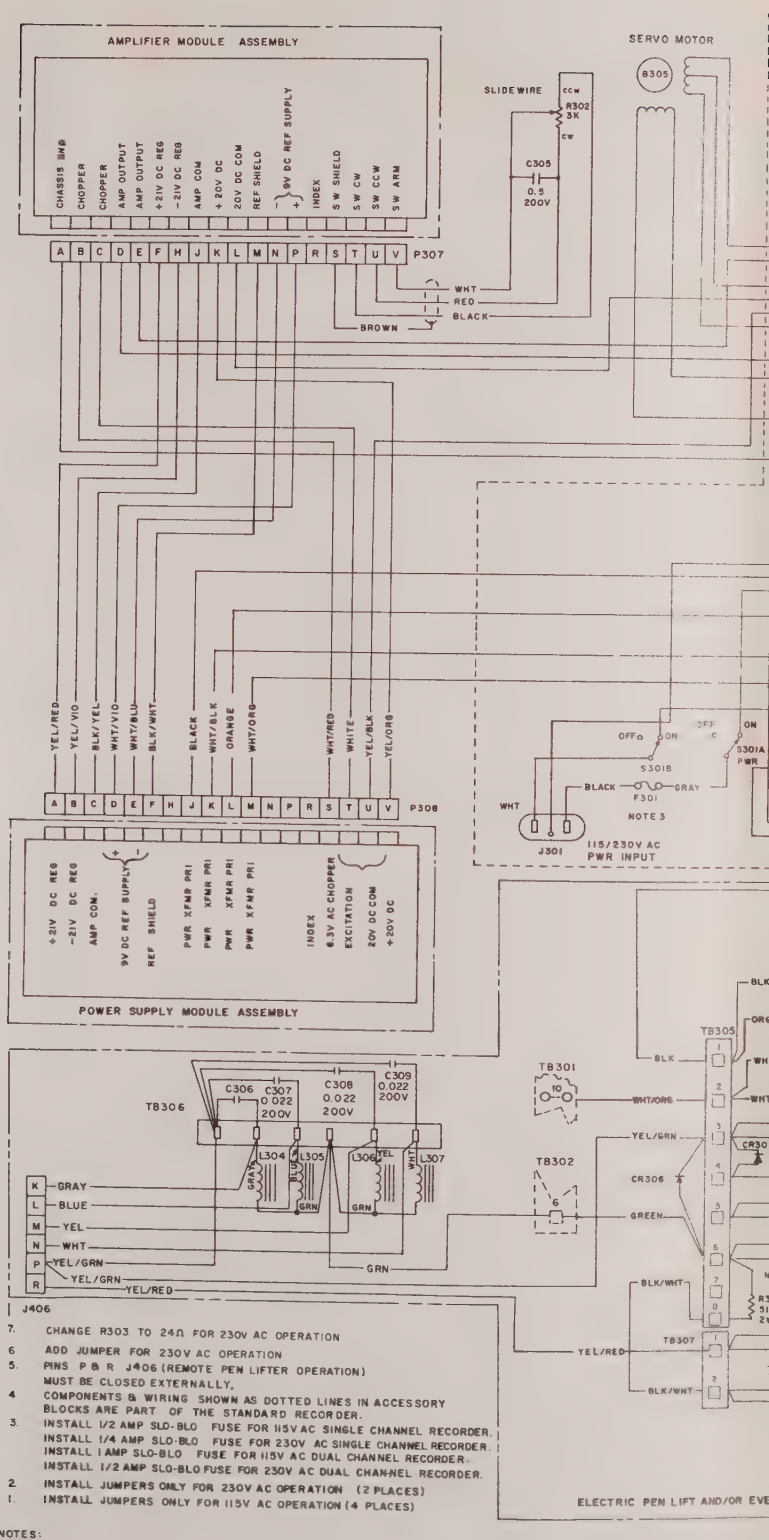
| Description | The Six Pack | Standard Pack | Super Pack |
|---|---|---|---|
| 10-inch chart paper, Series 1A | 6 rolls chart paper; | 12 rolls chart paper; | 18 rolls chart paper; |
| 0.85-cc cartridges of ink, 908-049 Series | 6 cartridges of ink;* | 12 cartridges of ink;* | 18 cartridges of ink;* |
| Pen Cleaning Kits | 1 pen cleaning kit. | 2 pen cleaning kits. | 4 pen cleaning kits. |

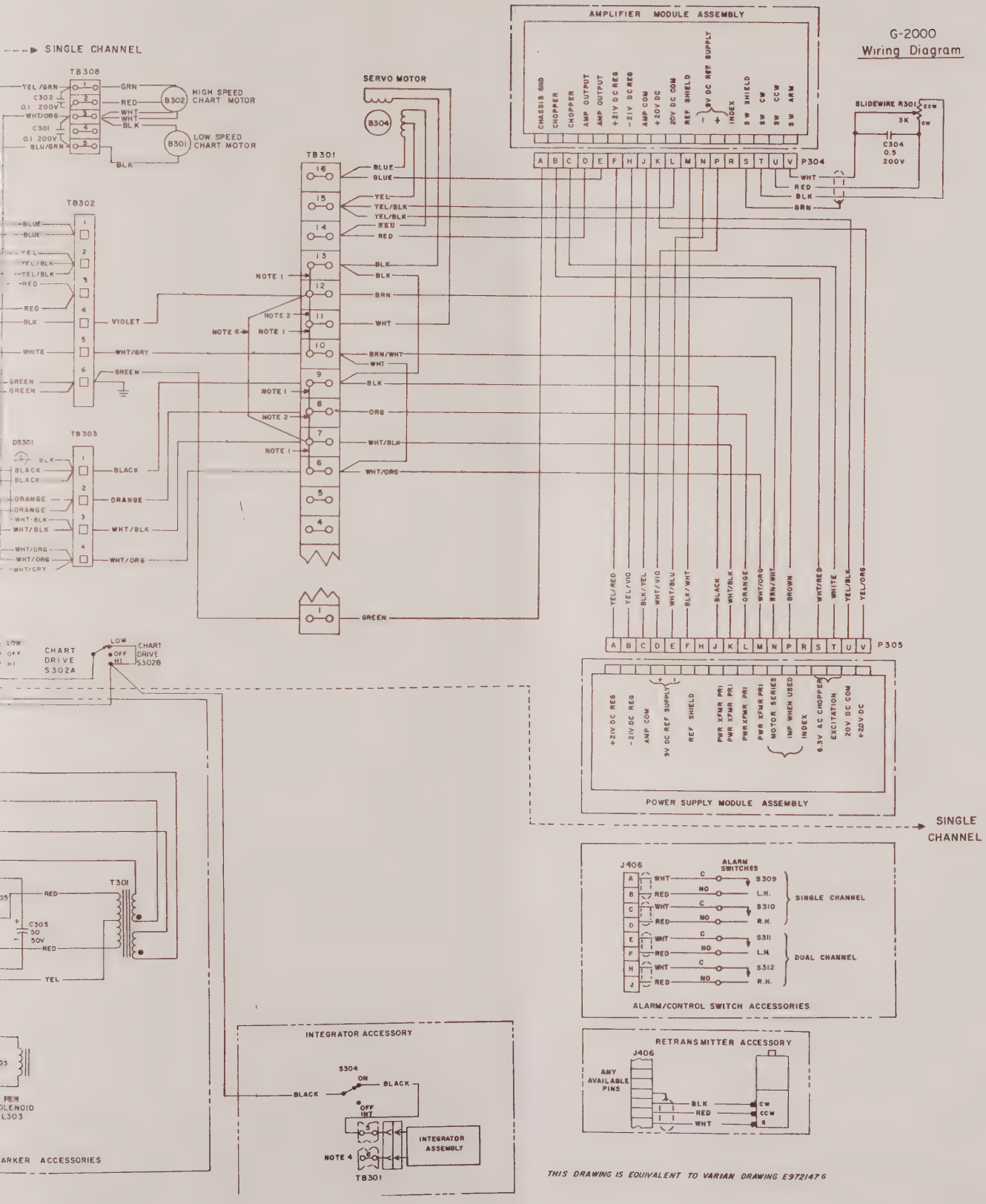
*Specify ink part number.

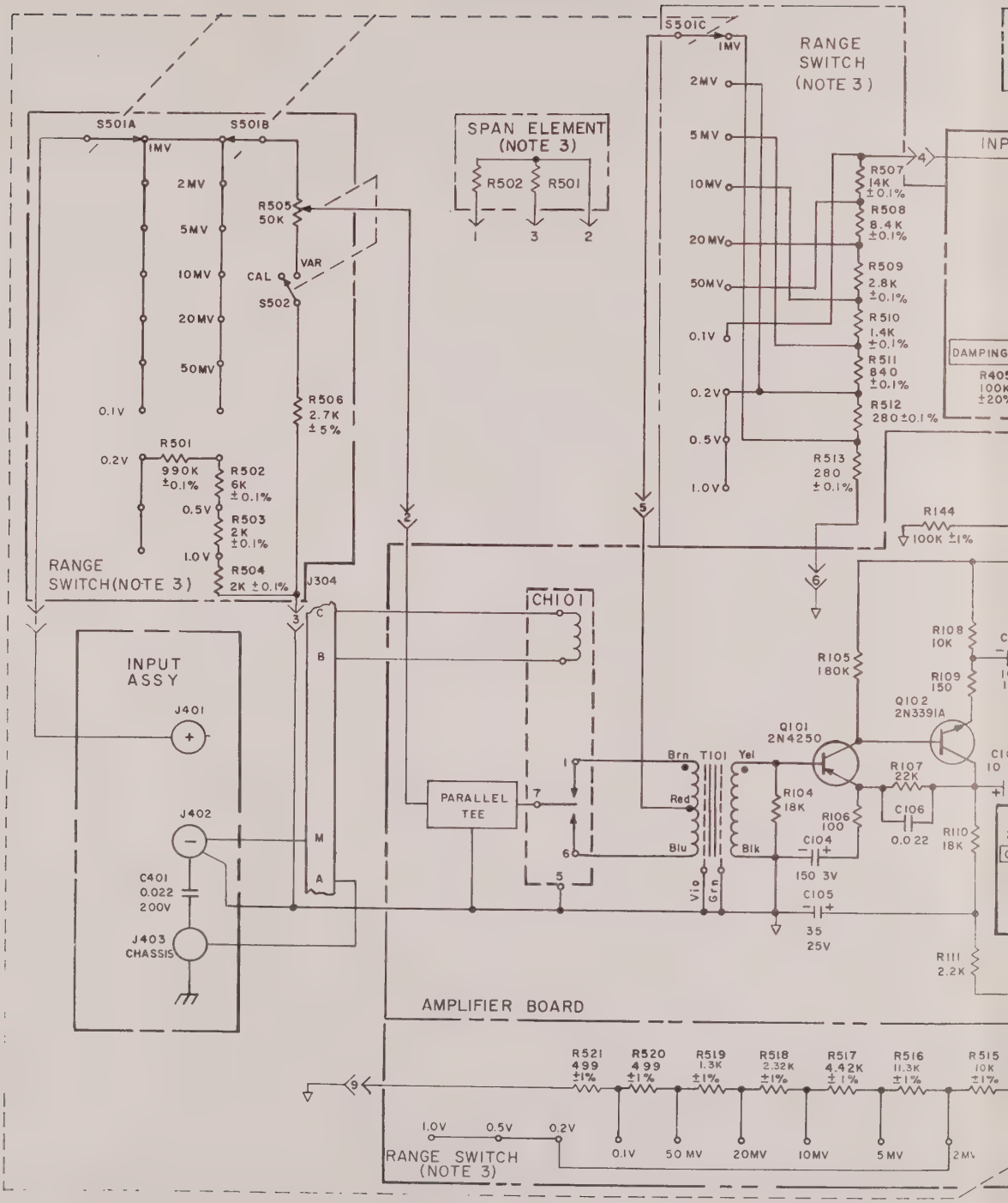
# SECTION 6
# SCHEMATIC DIAGRAMS

This section contains the following schematic diagrams:

| Varian Part Number | Title |
|---|---|
| 972-147 | Wiring Diagram |
| 972-537 | Amplifier Schematic |
| 972-263 | Power Supply Schematic |
| 972-569 | Parallel T Schematic |


AMPLIFIER MODULE ASSEMBLY
CHASSIS GND
CHOPPER
CHOPPER
AMP OUTPUT
AMP OUTPUT
+21V DC REG
-21V DC REG
AMP COM
+20V DC
20V DC COM
REF SHIELD
9V DC REF SUPPLY
INDEX
S W SHIELD
S W CW
S W CCW
S W ARM
A B C D E F H J K L M N P R S T U V P307
SERVO MOTOR
B305
SLIDEWIRE
CCW
R302 3K
CW
C305 0.5 200V
WHT
RED
BLACK
BROWN
YEL/RED
YEL/VIO
BLK/YEL
WHT/VIO
WHT/BLU
BLK/WHT
BLACK
WHT/BLK
ORANGE
WHT/ORG
WHT/RED
WHITE
YEL/BLK
YEL/ORG
A B C D E F H J K L M N P R S T U V P308
OFF
ON
S301B
S301A PWR
BLACK
GRAY
F301
NOTE 3
WHT
J301
115/230V AC PWR INPUT
POWER SUPPLY MODULE ASSEMBLY
+21V DC REG
-21V DC REG
AMP CON.
9V DC REF SUPPLY
REF SHIELD
PWR XFMR PRI
PWR XFMR PRI
PWR XFMR PRI
PWR XFMR PRI
INDEX
6.3V AC CHOPPER EXCITATION
20V DC COM
+20V DC
TB306
C306 C307 0.022 200V
C308 0.022 200V
C309 0.022 200V
L304
L305
L306
L307
K GRAY
L BLUE
M YEL
N WHT
P YEL/GRN
R YEL/GRN
YEL/RED
GRN
TB301
TB302
TB305
TB307
BLK
WHT/ORG
YEL/GRN
CR306
GREEN
BLK/WHT
YEL/RED
BLK/WHT
J406
7. CHANGE R303 TO 24Ω FOR 230V AC OPERATION
6 ADD JUMPER FOR 230V AC OPERATION
5. PINS P & R J406 (REMOTE PEN LIFTER OPERATION) MUST BE CLOSED EXTERNALLY.
4 COMPONENTS & WIRING SHOWN AS DOTTED LINES IN ACCESSORY BLOCKS ARE PART OF THE STANDARD RECORDER.
3. INSTALL 1/2 AMP SLO-BLO FUSE FOR 115V AC SINGLE CHANNEL RECORDER.
INSTALL 1/4 AMP SLO-BLO FUSE FOR 230V AC SINGLE CHANNEL RECORDER.
INSTALL 1 AMP SLO-BLO FUSE FOR 115V AC DUAL CHANNEL RECORDER.
INSTALL 1/2 AMP SLO-BLO FUSE FOR 230V AC DUAL CHANNEL RECORDER.
2. INSTALL JUMPERS ONLY FOR 230V AC OPERATION (2 PLACES)
1. INSTALL JUMPERS ONLY FOR 115V AC OPERATION (4 PLACES)
ELECTRIC PEN LIFT AND/OR EVE
NOTES:


G-2000
Wiring Diagram
SINGLE CHANNEL
AMPLIFIER MODULE ASSEMBLY
CHASSIS GND
CHOPPER
CHOPPER
AMP OUTPUT
AMP OUTPUT
+21V DC REG
-21V DC REG
AMP COM
+20V DC
20V DC COM
REF SHIELD
9V DC REF SUPPLY
INDEX
SW SHIELD
SW CW
SW CCW
SW ARM
P304
SLIDEWIRE R301
3K
C304
0.5
200V
SERVO MOTOR
B304
TB8308
HIGH SPEED CHART MOTOR
B302
LOW SPEED CHART MOTOR
B301
TB8302
TB303
TB301
NOTE 1
NOTE 2
NOTE 6
P305
POWER SUPPLY MODULE ASSEMBLY
+21V DC REG
-21V DC REG
AMP COM
9V DC REF SUPPLY
REF SHIELD
PWR XFMR PRI
PWR XFMR PRI
PWR XFMR PRI
PWR XFMR PRI
MOTOR SERIES
IMP WHEN USED
INDEX
6.3V AC CHOPPER EXCITATION
20V DC COM
+20V DC
CHART DRIVE S302A
CHART DRIVE S302B
T301
C305
50
50V
SINGLE CHANNEL
J406
ALARM SWITCHES
S309
S310
S311
S312
L.H.
R.H.
SINGLE CHANNEL
DUAL CHANNEL
ALARM/CONTROL SWITCH ACCESSORIES
INTEGRATOR ACCESSORY
S304
ON
OFF INT
INTEGRATOR ASSEMBLY
RETRANSMITTER ACCESSORY
ANY AVAILABLE PINS
CW
CCW
ARKER ACCESSORIES
THIS DRAWING IS EQUIVALENT TO VARIAN DRAWING E9721476



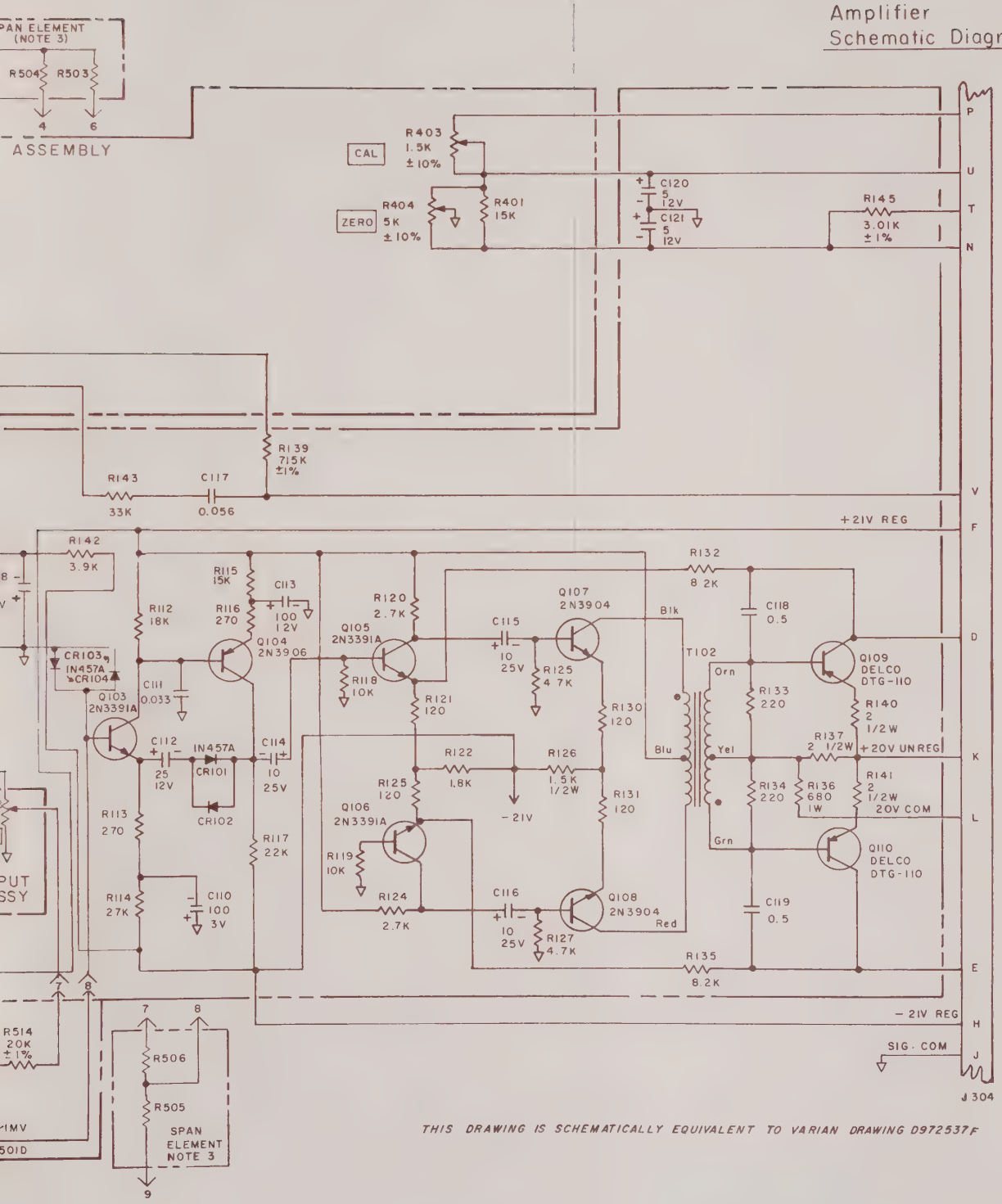

RANGE SWITCH USED WITH MULTISPAN RECORDER
SPAN ELEMENT USED WITH FIXED SPAN RECORDERS

2 UNLESS OTHERWISE SPECIFIED.
ALL RESISTOR VALUES IN OHMS, 1/4 WATT, ±5%
ALL CAPACITOR VALUES IN MICROFARADS, 200V, ±20%

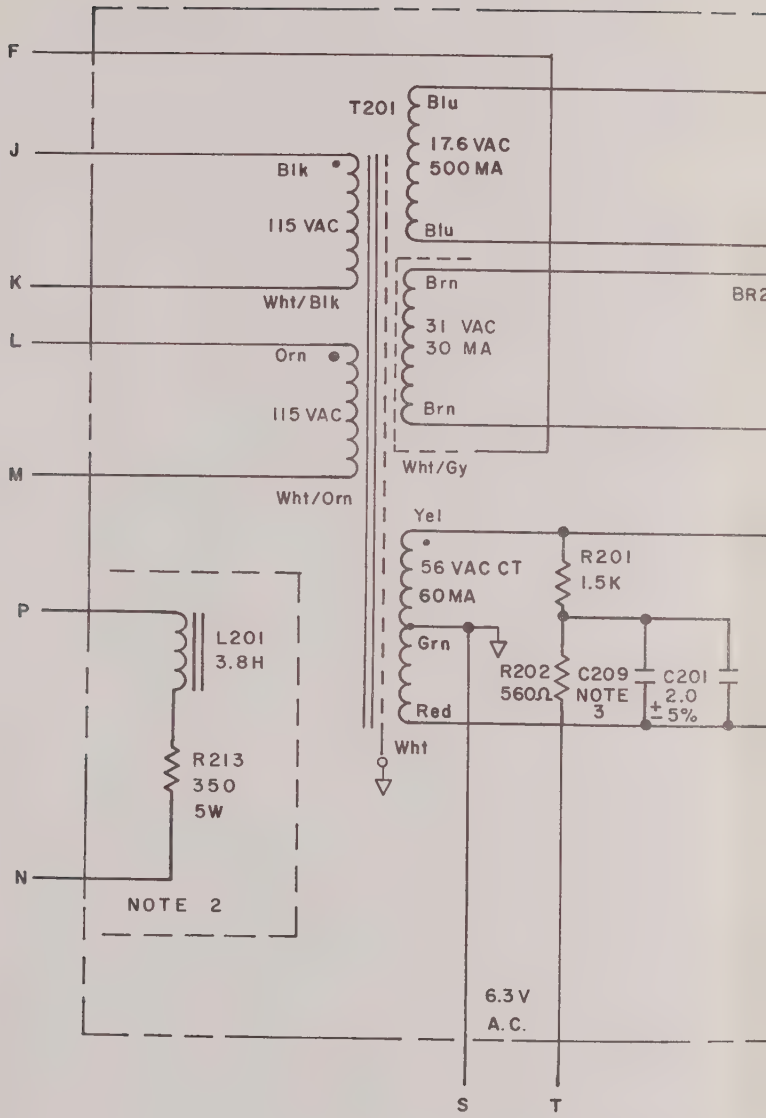
1 ⏚ CHASSIS GROUND. ▽ SIGNAL GROUND; DC ISOLATED FROM EACH OTHER

NOTES:

# Amplifier Schematic Diagram



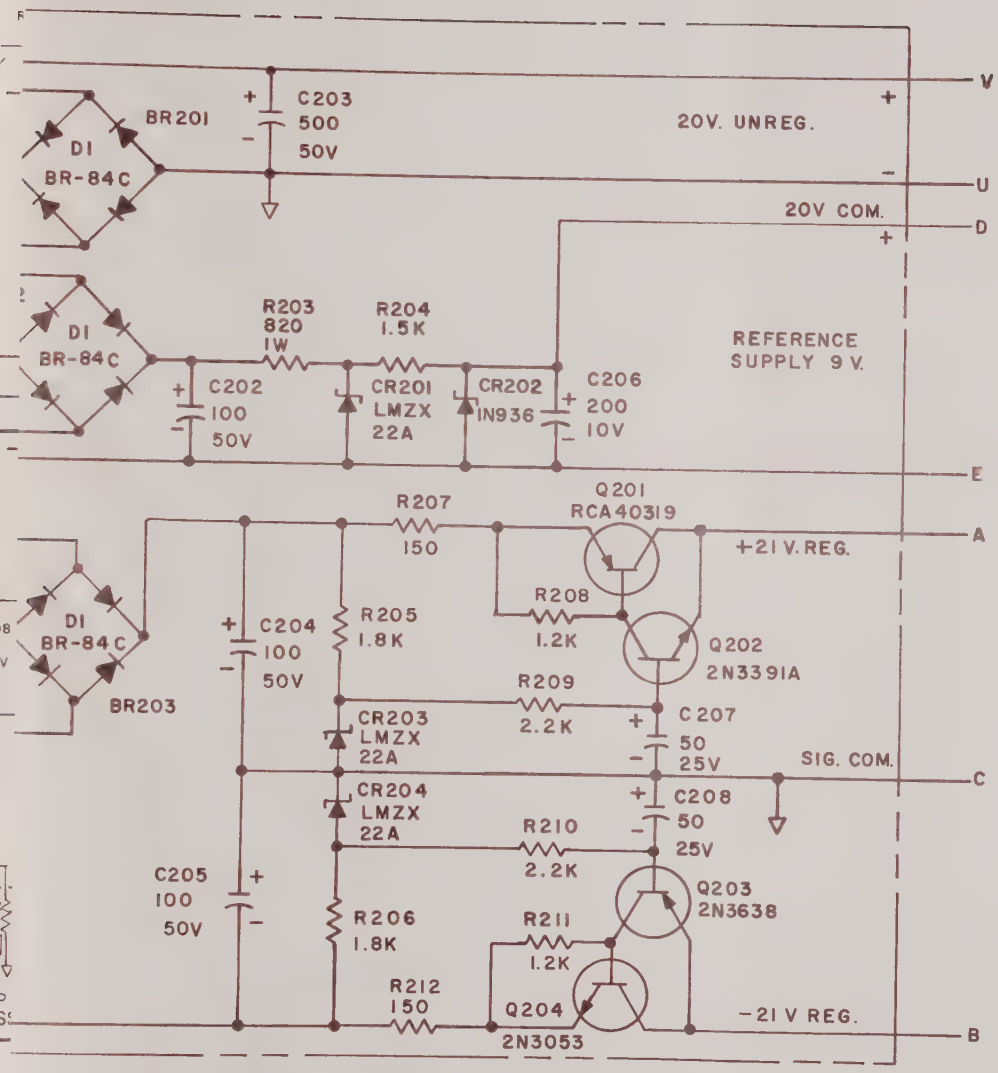

*THIS DRAWING IS SCHEMATICALLY EQUIVALENT TO VARIAN DRAWING D972537F*




3. FOR 60HZ OPERATION C209 IS 0.5 μf 200V 5%
   FOR 50HZ OPERATION C209 IS 1.0 μf 200V 5%
2. L201 AND R213 USED ON SINGLE CHANNEL 230 VOLTS AC
1. UNLESS NOTED OTHERWISE:
   ALL RESISTORS
   EXPRESSED IN OHMS
   1/4 WATT
   ±5%
   ALL CAPACITORS
   EXPRESSED IN MICROFARADS
   200V

NOTES: ±20%

# Power Supply Schematic Diagram




*THIS DRAWING IS SCHEMATICALLY EQUIVALENT TO VARIAN DRAWING C972263B*

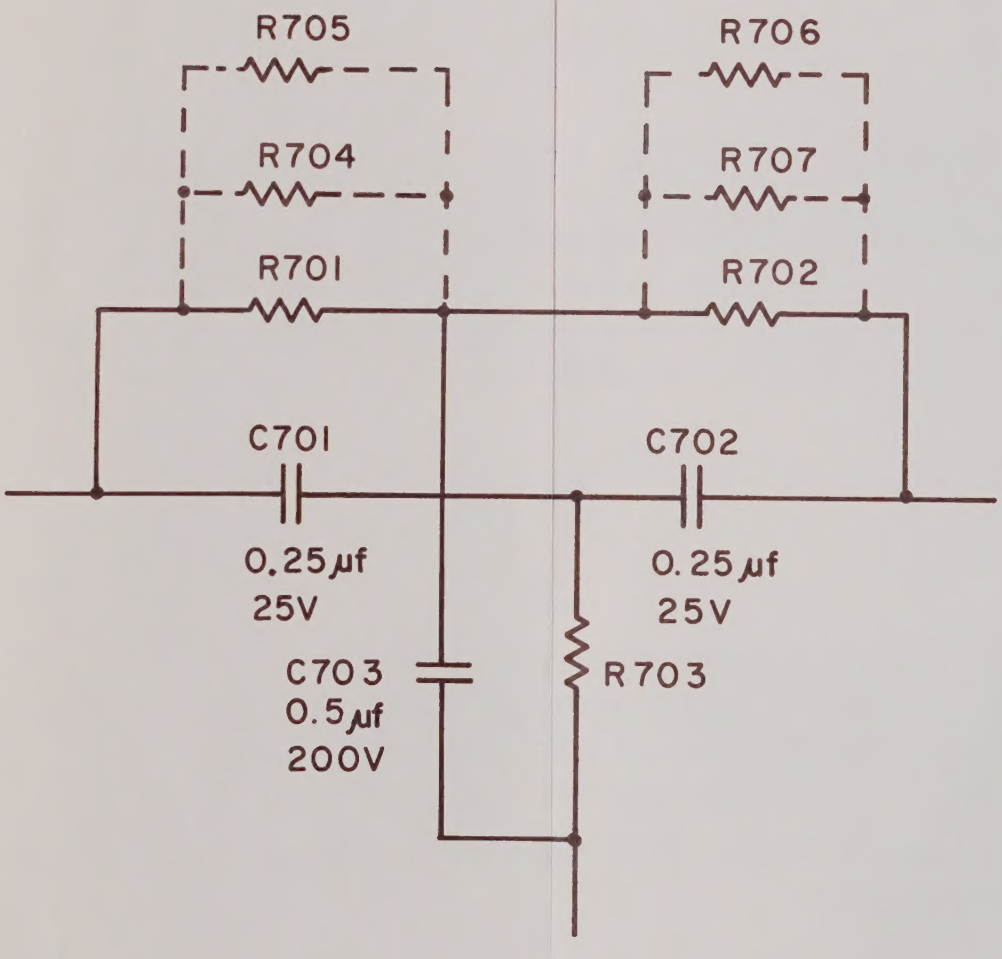
| RESISTANCE VALUE TABLE 50Hz & 60Hz | | |
|---|---|---|
| SCHEMATIC REF. NO. | 50Hz | 60Hz |
| R701 | 13.7K | 11.3K |
| R702 | 13.7K | 11.3K |
| R703 | 6.81K | 5.62K |

2. RESISTORS SHOWN IN DOTTED LINES SELECTED IN TEST FOR 50 OR 60Hz REJECTION RATIO OF AT LEAST 60 Db FROM A 600 OHM SOURCE IMPEDANCE.

1. ALL RESISTORS ±1%, UNLESS OTHERWISE SPECIFIED.

NOTES:

## Parallel Tee (50 and 60 Hz) Schematic Diagram




*THIS DRAWING IS SCHEMATICALLY EQUIVALENT TO VARIAN B972569A*

www.manualsplus.com
1034895